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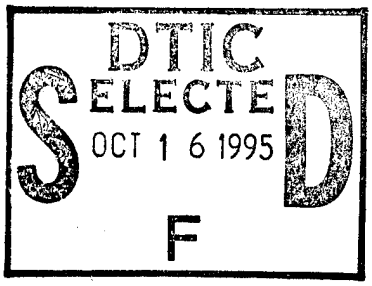
INNOVATIVE APPROACH TO FUSION TESTBED TO INTEGRATE MULTIPLE SENSOR DATA

CSC Professional Services Group

Gerald A. Bright, Robert S. Mandry, and Mark D. Barnell



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APPROVED: Richard R. Gassner

RICHARD R. GASSNER
Project Engineer

FOR THE COMMANDER: Donald W. Hanson

DONALD W. HANSON
Director of Surveillance & Photonics

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Gerald D. Bright, Robert S. Mandry, and Mark D. Barnell

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
CSC Professional Services Group
1360 Fairview Park Drive
Falls Church VA 22042

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13. ABSTRACT (Maximum 200 words)
Rome Laboratory (RL) OCSM directorate is actively developing a Multisensor Data Fusion Tracking Testbed capability for evaluating, testing, and developing fusion algorithms. This report describes the work performed by CSC Professional Services Group to improve this testbed by extending the innovative work started earlier in support of the testbed by adding the variable configuration capability to the algorithms and data sources. The results of this work have included the following: (1) review, analysis, and update of existing multisensor fusion algorithms for improved performance; (2) upgrade of the sensor fusion functions for testing performance in the testbed, including the real-time display; and (3) development of a GUI driven algorithm post-test analysis tool.

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1.0 Introduction:

Rome Laboratory is developing several abstract methods of combining surveillance sensor data into tracks. These combination methods are known as Fusion Algorithms. To test these algorithms, Rome Laboratory's OCSM branch is actively developing a Sensor Data Fusion Tracking Testbed (SDFTB). This testbed provides a configurable framework for exercising, and comparing the performance of fusion algorithms. Having worked with configurable testbeds in the past, CSC personnel developed an innovative approach to implementing a variable configuration multisensor test capability in a cost effective manner. CSC presented this approach to Rome Lab, and in a previous contract applied this approach to the development of their Sensor Data Fusion Tracking Testbed. The objective of this contract is to extend the innovative work started earlier in support of the development of the testbed by adding the variable configuration capability to the algorithms and data sources. Specifically, the objective of this contract is to:

(1) Review and analyze existing multisensor fusion algorithms to identify their integration requirements,
(2) Develop the sensor fusion integration functions identified in 1,
(3) Analyze the existing SDFTB to identify deficiencies, and
(4) Provide real-time display and post test algorithm performance analysis by enhancing the capabilities of the SDFTB.

This report summarizes the work performed by CSC Professional Services Group from October 1, 1994 to March 17, 1995 to fulfill those objectives. In pursuit of those objectives CSC personnel have additionally contributed to or solely developed:

(1) The Multisensor-Multitarget Data Fusion using an S-Dimensional Sliding Window Assignment Algorithm, (S-D) [2]
(2) an upgraded and validated Multisensor Air Traffic Surveillance (MATSurv) 2-dimensional fusion algorithm, [1]
(3) an improved testbed sensor interface,
(4) a set of post analysis data interface functions communicating with,
(5) a GUI driven algorithm performance post analysis tool, and
(6) testbed operational instructions, configuration documentation and functional flow diagrams.

The description of the work performed on each of these efforts along with the supporting documentation will be included or referenced in this final report. This report extends the documentation efforts started under the "Innovative Approach to the Development of a Variable Configuration Multisensor Test Capability Final Report", published under Contract F30602-94-C-0058. [3]

2.0 Algorithm and Testbed Work

Rome Lab's OCSM branch has been active in the area of sensor data fusion since the early 80's. Considerable in-house work was accomplished in the late 1980's. The non-object oriented, evolutionary development of testbed software during this period resulted in the lack of overall extendibility. As a result only one track fusion algorithm methodology, Multiple Hypothesis Tracking (MHT) was implemented.

This contract extends the capability of the newly developed SDFTB which is an object-oriented approach to the design and implementation of a Fusion Testbed. This testbed provides a variable configuration capability to the test engineers at Rome Lab.

2.1 Algorithm Review

As part of this contract CSC was to review and analyze existing multisensor fusion algorithms developed by the government to include those under development. Three algorithms fell under this preview. The first is the Nearest Neighbor Association / Alpha/Beta Tracker algorithm. To the testbed operator this tracker is known as the Type 0 tracker. The second is the Multisensor Air Traffic Surveillance, (MATSurv) tracking algorithm known as the Type 1 tracker. The third is the " Multisensor-Multitarget Data Fusion using an S-Dimensional Sliding Window Assignment algorithm", (S-D) not yet installed in the Fusion Testbed. We have reviewed each of these algorithms and have identified their Fusion Testbed interface requirements.

2.1.1 The Type 0 tracker, (Nearest Neighbor/AlphaBeta) tracker requires coordinate system interface upgrades to utilize the new coordinate system we developed and installed in the testbed. The new coordinate system transformations support standardization of the testbed coordinate systems and provide the internal data communication transformations.

2.1.2 The Type 1 tracker, (MATSurv), 2-dimensional multisensor detection to multitrack fusion algorithm/tracker was fully integrated, analyzed and tested using the new testbed coordinate systems, and new post analysis capability. In addition the interface requirement review discovered that the type 1 tracker expected sensors reports to come as complete scans. To get the algorithm to operate properly the Fusion Testbed required the option to force the sensors to report the detection sets as a complete scan so the algorithm would not associate more than one detection from each scan to a track. This upgrade was implemented by modifying the Data Interface Unit (DIU) code to group and store the blocks of sensor reports until a sensor had completed a physical scan and then at that time allow the fusion algorithm access to the data.

2.1.3 The S-Dimensional Sliding window Assignment algorithm, was still under development at the time of this contract. During this contract period we provided interface definitions and interface functions to minimize the work required to install the algorithm in the Fusion Testbed. The installation is expected to require only a minimal software effort because the algorithm developer was kind enough to support our requirements and use the code. All coordinate systems match, and the interfaces are identical to the standards as defined in the testbed. An area of concern with this algorithm is it's hardware requirements. We have observed baseline tests of this association and tracker and have noted that even under minimal threat conditions the algorithm requires more runtime storage space than presently available on the Fusion Testbed host platform.

2.2 Capabilities Added to the Rome Lab Fusion Testbed

2.2.1 Sensor Data Interface Modifications

The Fusion Test Bed has many sensor class input options. One in particular, the scanning sensor class input was modified to group the sensor reports into complete scans. To do this the data interface unit (DIU) function code was modified to utilize an input flag that indicated if that report was the last of a particular scan. When the report was not the last the code was modified to maintain the partial scan detection list and wait for the scan to complete. After the report grouping was modified the algorithm performance improved but a few target tracks were still split into two sections. After careful review of the input data set we discovered that a few detections were missing. The missing detections were being ignored during data acquisition. Further review uncovered a valid detection type was missing from the detection type list. These detection types were added to the list and all tracks are now maintained throughout their target's flight.

2.2.2 Post Analysis

The Fusion Testbed needed some way, other than real-time plotting of the tracks in Latitude and Longitude, to evaluate the performance of the algorithms. Under this contract we have provided that capability. To do this we performed a review of analysis approaches and the associated sets required. From this we developed the specifications for a post test algorithm performance analysis tool. The specifications were then utilized to develop post analysis data definitions, and using the definitions we developed an output/storage function library. The library is available to an algorithm installer. Using the library the installer can easily modify the tracker algorithms to save the defined data sets during installation of an algorithm into the testbed. Once added to the algorithm, the output/storage functions automatically provide the data necessary and in the correct format to perform post test performance analysis (post analysis) on an algorithm.

The output/storage functions document time, data type, units and coordinate system of each stored value during the running of the testbed. These values are then used as input to the post analysis tool developed by CSC. This tool has a menu driven analysis selection section that generates the performance analysis data sets. The purpose of this section of the tool is to map raw measurement and results data into the tool and to reformat the data for post analysis. Thus, the menu driven section of the tool allows the user to 1) map the raw scan measurement data and track data and their units into the tool and then to request analysis/plot set generations.

For the raw measurement scan data performance set generation options are to generate:

1. Scan list - (Scan Number, Location, # of Detects and Time)
2. Target list - (IFF and # of Detects)
3. All Scans measurement set - (Time, Lat., Long., Alt.)
4. Single Scan measurement set - (Time, Lat., Long., Alt.)
5. Target ID measurement set - (Time, Lat. Long., Alt.) ----- - Ideal Association

For the Track data performance set generation the option are to generate:

1. All Tracks point set - (Time, Lat., Long., Alt.)
2. Single Track point set - (Time,. Lat., Long., Alt.)
3. Track with Associated Detections set - (Time,. Lat., Long., Alt.)
4. Track Association Costs set - (Negative Log Likelihood)
5. Track Innovation set (Detection - Track)
6. Track Target ID set (List of Target Id / Associated Detection)
7. Track Covariance set (Covariance Ellipse generation data)
8. Target ID set (all measurements of selected ID number)

Once a performance set has been generated the analysts can list, plot, and hardcopy the performance data using a graphical user interface (GUI) driven display and plot package. The major GUI options support:

1. Two and Three Dimensional Plotting,
2. Axis Selection, Scale, and Orientation,
3. Data Point Labeling,
4. Hardcopy Selection, and
5. Data Subset Selection.

The details of the data set generation, analysis, and display/hardcopy options are presented in Appendix A of this document.

2.2.3 Fusion Testbed Configuration, Control and Real-time Performance Display

The Fusion Testbed requires modification to provide the test operator the best possible user interface to the testbed. The testbed user interface presently uses a command file type of user interface. We have striven to help define and prepare for this upgrade during this contract period. To help define the new testbed configuration, control and performance display capabilities we have reviewed the present interface capabilities and user interface libraries. During this review we have noted that the Fusion Testbed host platform at Rome Lab is under going a windows software library upgrade. The library upgrade is an upgrade of the X windows graphical interface software.

At the start of this contract the Fusion Testbed display objects utilized code developed using the widgets from version 2.0 of the OpenLook Intrinsic Toolkit (OLIT 2.0). This toolkit has since been upgraded. To maintain compatibility with future graphical efforts expected to run on the Fusion Testbed's host platform the testbed code display object needed to be upgraded to use the new version. (OLIT 3.0).
The display object code is that code that handles the requests to display to the test bed operator the latest status of the measurements and track data point values in a two dimensional plot. The display object shows the geographical map of the earth background overlaid with the radar sensor detections. As the tracker developed fussed tracks the display is also overlaid with the fused track update data points.

Along with the widget library upgrade a Graphical User Interface, (GUI) type user interface is desired for testbed operational control. Here the user will use a mouse to select from testbed configuration and operation functions to run his or her desired algorithm performance tests. In pursuit of this we have developed a GUI using Devguide and documented the design in the final report, "Innovative Approach to the Development of a Variable Configuration Multisensor Test Capability" accomplished under contract F30602-94-C-0058. [3] Devguide also uses widgets from OLIT 3.0, another reason the upgrade to 3.0 was required.

To implement the display object code upgrade we first tried to recompile the testbed with the OLIT 3.0 library replacing the 2.0 version. The compile failed. The libraries appeared to be incompatible. A review of the display objects code indicated that to learn where the incompatibilities were for such a complex code would take more time than originally allotted to this effort. To attack the problem we decided to first upgrade a much smaller display function that was a standalone tool. During the upgrade of the tool we did identify the incompatibilities and determined how to upgrade the Fusion Testbed display object. The present display software has been recompiled with OLIT 3.0 and is performing as expected.

2.3 Modifications made to the MATSurv Algorithm

As discussed in 2.1.2 the Type1, (MATSurv), 2-Dimensional Multisensor Detection to Multitrack Fusion algorithm/tracker was fully integrated, analyzed and tested

using the new testbed coordinate systems, and the new post analysis capability. During the testing an error was found and corrected. The error had to do with coordinate definitions, in particular the trackers local coordinates. The correction will be discussed in section 2.3.3. Additionally, we were asked to upgrade the algorithm. One upgrade request was to modify the algorithm to use a spatial association gate as opposed to a velocity association gate and is discussed in section 2.3.1. A second upgrade was to develop and include a drop tracks function for the MATSurv algorithm. That upgrade is discussed in section 2.3.2. After all these modifications were made we ran a performance analysis on the algorithm versus a baseline test case. The performance analysis is presented in section 2.3.4.

2.3.1 Spatial Gate Upgrade

During preliminary testing of the algorithm, the algorithm performance review by Rome Lab engineering determined that when a target was viewed by two sensors at very nearly the same time, one of the detections was NOT associated with the track. Rome Lab personnel knew the algorithm used a velocity gate to remove unlikely associations from the computations and they were suspicious as to how the calculations would handle the velocity gate velocity computation when delta time approached zero. They checked the processing and discovered that once a track had been updated by the first detection the track time was updated to that time of that detection. Then, when the second detection was processed, it being measured at very nearly the same time, it forced the time difference between track time and detection time to approach zero. As the delta time approached zero the velocity calculation (track to detection separation / delta time) approached infinity. A near infinity value caused the velocity gate to throw out the association and thus the detection was never used to update the track. Worse yet, the unused detection started a new track.

To correct the problem we suggested replacing the velocity gate with a spatial gate, not a simple spatial gate, but spatial gate based on the time since last update and the sensor's spatial measurement accuracy. The idea of the spatial gate is to compute the space a valid maneuvering target could still be observed in after a given amount of time has elapsed. If no time had elapsed the space is calculated to be bounded by the track covariance values. If time has elapsed between measurements, the space is enlarged to account for the target having traveled at a maximum velocity, the maximum velocity as used in the original velocity gate function.

This spatial gate function was written by CSC and used to replace the velocity gate. To develop the zero time spatial gate the track covariance eigenvalues were calculated and used to determine the three dimensional track covariance values representing the spatial gate. Testing with the new gate showed correct association of measurements of the same target from two different sensors at the same time.

2.3.2 Addition of a Drop Tracks Function

Testing of the MATSurv algorithm included tests where measurement without an associated IFF beacon return were allowed to pass as detections. These detections are known as skin returns. When testing with skin returns without an associated IFF, a large amount of these returns were due to noise. These false detections caused the algorithm to develop a very large number of false tracks. They were just tracks initiated on noise. All these active false tracks were slowing down the algorithm so we were asked to develop a drop tracks function.

The drop tracks function we developed for the MATSurv algorithm is based on the time since last track update. The drop track function scans active tracks to determine the time since last update and if the time is too large removes the track from the active track list, packs the list, but does NOT renumber the tracks. The dropped track data points and track number are saved in a drop track file in the working directory of the test bed. After the drop tracks function was installed and tested, processing times improved by a factor of 3 when the drop track time without an update limit was set to 60 seconds.

2.3.3 Minor Correction to Track Covariance Usage

During preliminary testing of the post analysis tool's track quality plot capability we became aware that the track quality covariance ovals seemed to be shaped inconsistently with the sensor measurement noise. Since we knew that sensor measurement noise contributes to the track covariance, we expected better alignment. Upon review we discovered that the MATSurv report's coordinate system documentation had a minor mislabel. This documentation error caused us to map the covariance results into the analysis tool incorrectly. The track covariance matrix was being generated correctly but the north and east axis usage during display was inverted because of the interpretation of the covariance matrix values based on mislabeled documentation. The algorithm developer was contacted and they concurred with our analysis. The algorithm was tracking properly, the appearance of the results was incorrect only because of the documentation error. We have corrected the error and the algorithm performance error ellipses in Section 2.3.4 are presented the ellipses correctly.

2.3.4 Verification of Correct Algorithm Installation

To validate correct installation of the MATSurv algorithm in the Fusion testbed we decided to compare the results of the algorithm running in the configurable Fusion testbed to the results of the algorithm running the developer's test case. To do this the Fusion Testbed was configured to generate the developers test case. To achieve the configuration the sensor suite was configured to include two L-band FAA radar located at Remsen and Dansville, NY. The two sensors were then requested to output the same measured data sets as the MATSurv developer used during their testing. The Fusion test bed was then configured to utilize the MATSurv algorithm, (Tracker Type 1) as the association and track algorithm combination.. The testbed display and post-analysis output

objects were selected to provide real-time display of the tracks and to record the same detailed performance data as was documented by the algorithm developer to present the algorithm's performance. This data set included:

Transformed Sensor Detections	(Time,Lat,Long,Alt),
Track Position Results	(Time,Lat,Long,Alt),
Track Covariance Matrix	(Track Local E-N-Up) and,
Association Cost	(Negative log-likelihood ratio)

Using this data the post-analysis tool was operated to evaluate the algorithm's performance. The first parameter evaluated was he total number of tracks. This value matched the developers results exactly. The second parameter evaluated was the number of detects in each track. This also matched exactly. If the tracks were of the same detections but at a slightly different position the association costs would differ slightly, these costs did not deviate from the developers cost over the complete run. Figure 1 shows the entire set of fused tracks generated using the two FAA radar.

This tests validate that the re-configuration capability, input/output parameter mapping, object interfaces, data transformations and algorithm have been successfully implemented as optional capabilities in the Fusion Testbed. For further algorithm performance information the reader is referred to Section 3.0 of this report. Section 3.0 walks the reader through all the steps performed to configure, run and analyze the performance of the MATSurv algorithm.

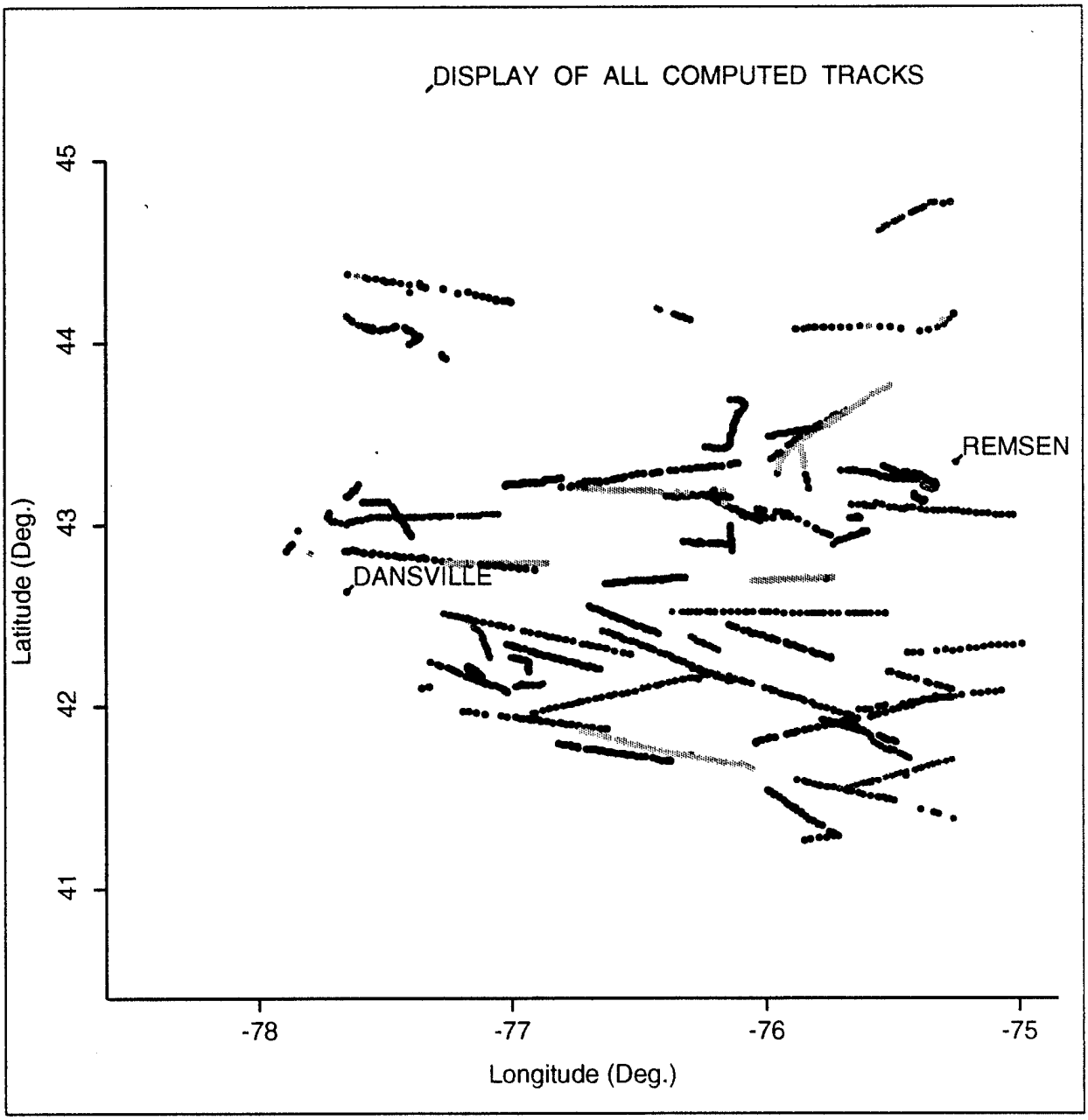


Figure 1 - Fused Tracks

3.0 Testbed & Tracker Operation

This section provides the reader with a structured walk through, presenting an example of how to operate the Fusion Testbed to exercise and evaluate the performance of a tracker. In this case the Type 1 tracker, (MATSurv) is exercised. Table 1, included at the end of this section organizes the operational information into a pullout check list.

Logging in ---

The first step in operating the Fusion Testbed is to gain access to the testbed runtime account. The present account is contained on the computer system JACOB in the OC fusion lab. The testbed user can gain access to JACOB by networking from an X-Windows terminal shell. The user then logs into the user account named MIST. After giving the correct password, the user should set the DISPLAY environment to the local machine.

3.1 Testbed Configuration Files - Block Diagrams - Flow Charts

The user, before starting to configure the testbed may wish to review a description of the testbed, it's coordinate systems and functional flow. If this is so, the user is directed to review the Appendix A of the "Multisensor Air Traffic Surveillance Tracker - Interface Design Document" of [3] before configuring the Fusion Testbed.

3.2 Testbed and Algorithm Parameter Inputs

At present, configuration options are selected by modifying four configuration files. The four files are contained in the "config" sub-directory. The files used in the MATSurv example are:

1. tracker_type1.config	Testbed Configuration File
2. t1_2D_Asoc_Kalman.config	Tracker Configuration File
3. display_UpstateNY_T0.config	Display Configuration File
4. suite_REMDAN_diuf.config	Sensor Suite Configuration File

The testbed configuration file contains the parameters and file directives to setup the testbed configuration. The parameters and files are:

Sensor Suite Configuration File
Display Configuration File
Type - Specific Configuration File
Track Frame Origin (latitude, longitude)
Maximum Velocity (nmi./hr)
Maximum Acceleration
Simulator0 Target File

Diu Formatted File
Ambis Formatted File
Ambis Host (latitude, longitude)
Number of Buttons
Button # 1
Perform Tracking Flag
Number of JSS Detection Tag Types
JSS Detection Tag # 1
JSS Detection Tag # .
JSS Detection Tag # .
JSS Detection Tag # N

The tracker configuration file contains the parameters and file directives to setup the tracker configuration. The parameters and files are:

Tracker type identifier,
Associator Name
Track Filter Name
Filter Control Variables by tracker type:
    Noise Model Parameters
    Drop Track Time
    Negative Time Limit
Association Control Variables by associator type:
    Maximum Target Speed
    Maximum Target Acceleration

The display configuration file contains the parameters and file directives to setup the display configuration. The parameters and files are:

Display Coordinate Origin (latitude, longitude)
Display Lower Right Origin (latitude. longitude)
Display Type
Background Map File
Artifact File
Number of History Points to Maintain
Detection Indicator Radius
Track Indicator Radius
Initial Display Dimension (Columns and Rows)
Erase Old Measurement Flag
Number of Buttons
Button #1

The sensor suite configuration file contains the information to setup the sensor suite. The parameters and file names are:

Number of Sensors in Suite
Data File
Sensor # 1 Configuration File
Sensor # N Configuration File

For each sensor in the suite, a sensor configuration file is used to select each of the sensor's operational settings or input parameter. The two files used in this case are found, each in their own sub-directory, under the "config" sub-directory. The files are:

1. remsen.config	Sensor Configuration File
2. dansville.config	Sensor Configuration File

The sensor configuration file contains the information to model sensor. The parameters are sensor dependent. An example set is:

Sensor Type
Sensor Beam Width
Scan Time
Sensor Location: (Lat., Long., Alt.)
Sensor Measurement Noise
Probability of Detect
Surveillance Region Volume

For all the configuration files the parameters and options are well documented in each file, and since this is only a temporary operational mode that will be replaced by a GUI driven options menu, we will not elaborate further. For now, the user edits and renames these files to set up his or her new Fusion Testbed configuration.

3.3 Operation and Results

After the configuration files have been edited and saved the user can start the test run by inputting the command:

```
tracker4  -f  tracker_type1.config
```

This command tells the tracker to start its operation and configure the testbed as described in the file -- tracker_type1.config. The testbed reads the specified file and that file identifies the tracker, display, and sensor suite files. These are in turn read and used to complete the configuration. Once configuration is complete the testbed executes using the data from the sensors and control values from the configuration files. In this case a display type 0 which causes a map of Upstate New York to be displayed with the sensors and their detections on a scan by scan basis. As the scans come in the Type 1 tracker,

(MATSurv) used the detections to generate fused tracks and the Display object is used to overlay the tracks on top of the detections. A simple magnifier window can be used on some workstations to magnify a selected area of the display. The display can be moved and sized to fit user preferences.

The user can watch the tracks develop and decide, in a visual way, if the algorithm is performing as expected. If things are going well the user lets the process run to completion, i.e. reach the end of all sensor scan data. At this time the display can be copied to hardcopy and the test case terminated by entering a Ctrl c.

3.4 Performance Analysis

During a test case run a tracker algorithm is busy storing selected input and output data sets to provide data for the Post Analysis Tool. In the case of the Type 1 tracker the data discussed in Section 2.3.4 has been saved along with the data units and column identification name. This data is contained in four files. The four are:

1. raw_data.col	data column names for the raw_data.dat file.
2. raw_data.dat	raw sensor data. ---- (detections).
3. measurements.col ---	data column names for the measurements.dat file.
4. measurements.dat ---	tracker response data. (tracks and covariance).

These data files are moved to the post-analysis sub-directory and the user sets the working directory to the post-analysis directory and enters ---- post ---- to start the post analysis tool. In the case of this example we moved the results of the tracker type 1 run to the post-analysis directory and generated the following plots to record the sensor detections and tracking fusing performance of the MATSurv algorithm.

Example Analysis --Track 15, IFF # 2111 with 31 detections.

Figure 2 shows the fused track labeled number 15 from the target with the IFF value of 2111. This post analysis plot matches the plot shown on page 17 of the MATSurv report [1]. Figure 3 shows a blow up of the same track on a Latitude and Longitude plot matching figure 8 on page 18 of the MATSurv report. Figure 4 shows an altitude Vs time plot for the same track that also matches the plot on page 18 of the same report. The only difference in this case is that the post-analysis plot is not normalized to the time of the first detection. The normalization capability is being added as this report is being written.

Example Analysis -- Track 46, changing IFF, 25 detections

Track 46 is a track which shows the association performance of the MATSurv algorithm. The aircraft is landing and for some reason the IFF changes before the plane

lands. The algorithm tracks the maneuvering plane and as shown in Figures 5 - 8 the post analysis tool can develop a wide variety of performance plots.

Figure 5 is a spatial latitude/longitude track plot,

Figure 6 is a blow up of the spatial plot with detection and track overlays including track covariance ellipses,

Figure 7 is an altitude track plot showing the plane landing, and

Figure 8 is a plot of the association cost used internally to weight the detection to track association decisions performed by MATSurv. These costs are the negative log of the likelihood that the detection was really associated with track 46.

These figures can be compared to the algorithm developers performance analysis plots shown in figures 12-23 of the MATSurv report [1].

Example Analysis -- Track 7 - outlier rejection, as presented in the MATSurv report.

Figures 9 and 10 duplicate the performance plots presented in the report used to indicate the MATSurv tracker performance in rejecting very noisy detections and fusing an incorrectly assigned ID detection. These figures can be compared to the figures 25 and 29 of the performance report. One may note the difference in orientation of the track covariance error ellipses. The post analysis plots show the correct orientation.

Example Analysis -- S Turn Track - Maneuvering Target Track.

Figure 11 plots the track of a target that was flown a prescribed flight path during the data acquisition period. During the observation period the pilot was directed to maneuver the aircraft to generate a S shaped turn. As shown in Figure 11 the testbed sensors detected the target and the association function associated the correct detections. These detections were fused into a very solid track that was maintained through out the maneuver.

How were these plots made? Appendix A of this report contains the user manual for the post analysis tool. The user should refer to the appendix to learn how to operate the tool.

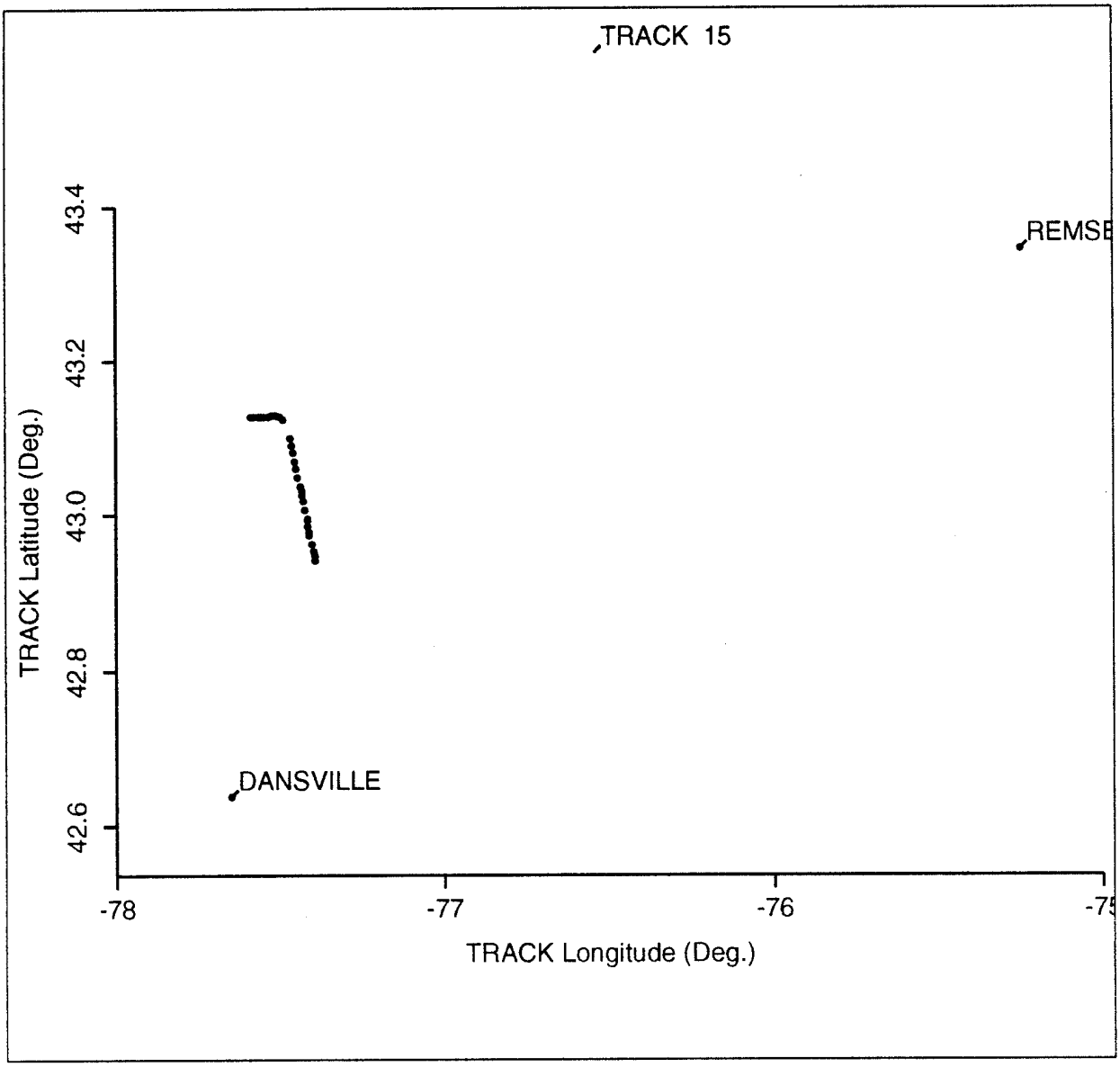


Figure 2 - Fused Track #15

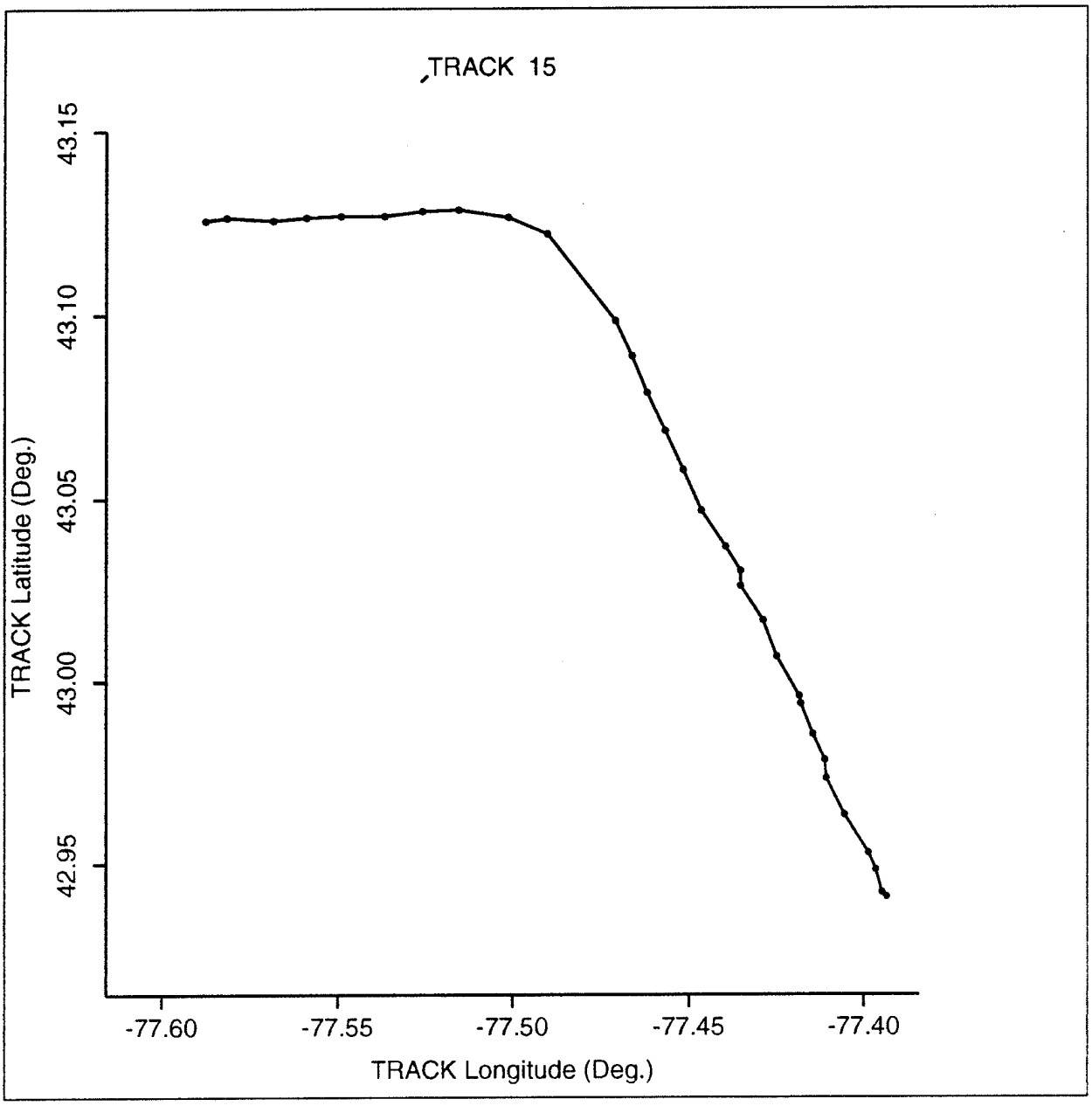


Figure 3 - Fused Track #15, Blowup

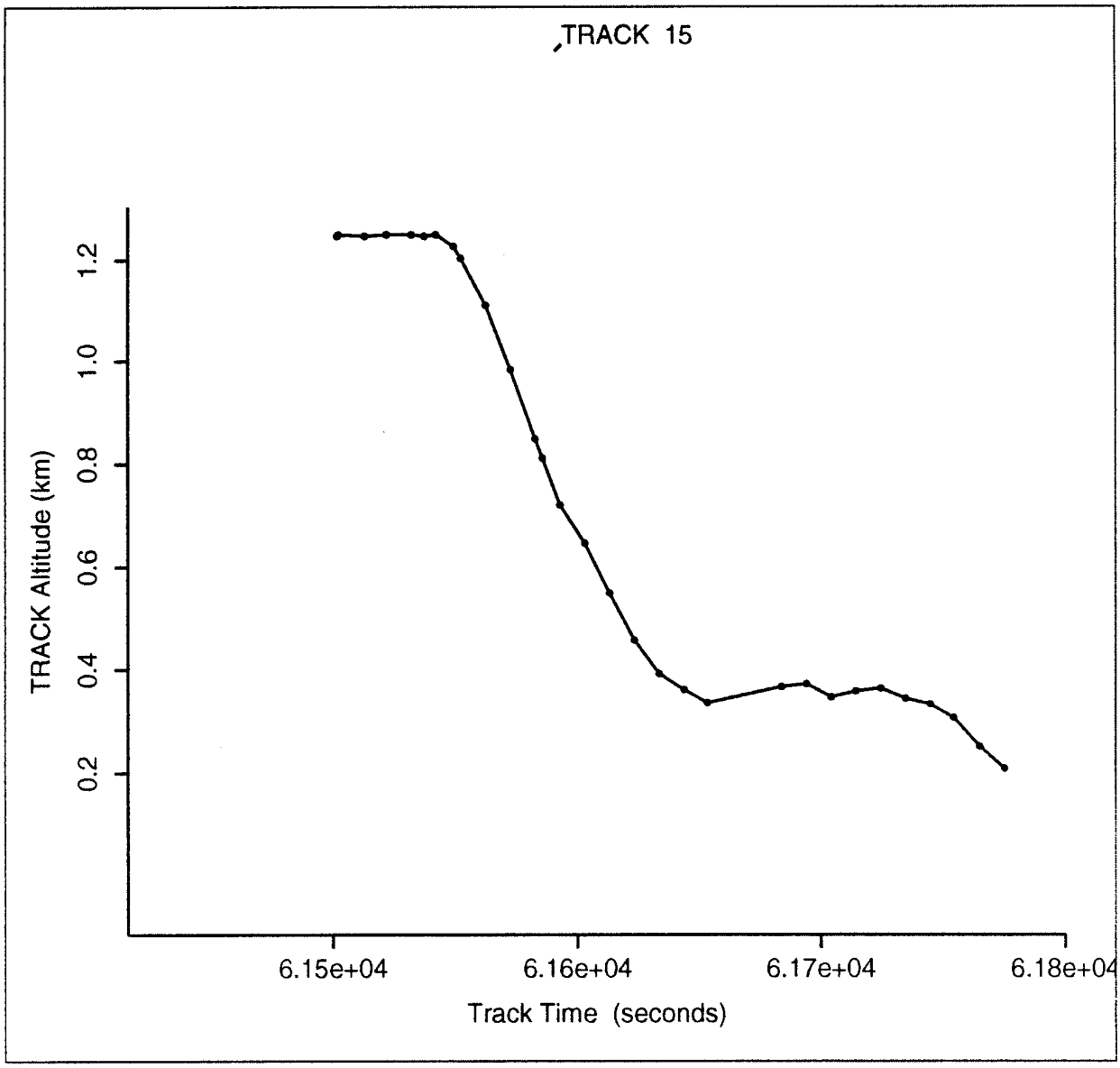


Figure 4 - Fused Track #15, Altitude Plot

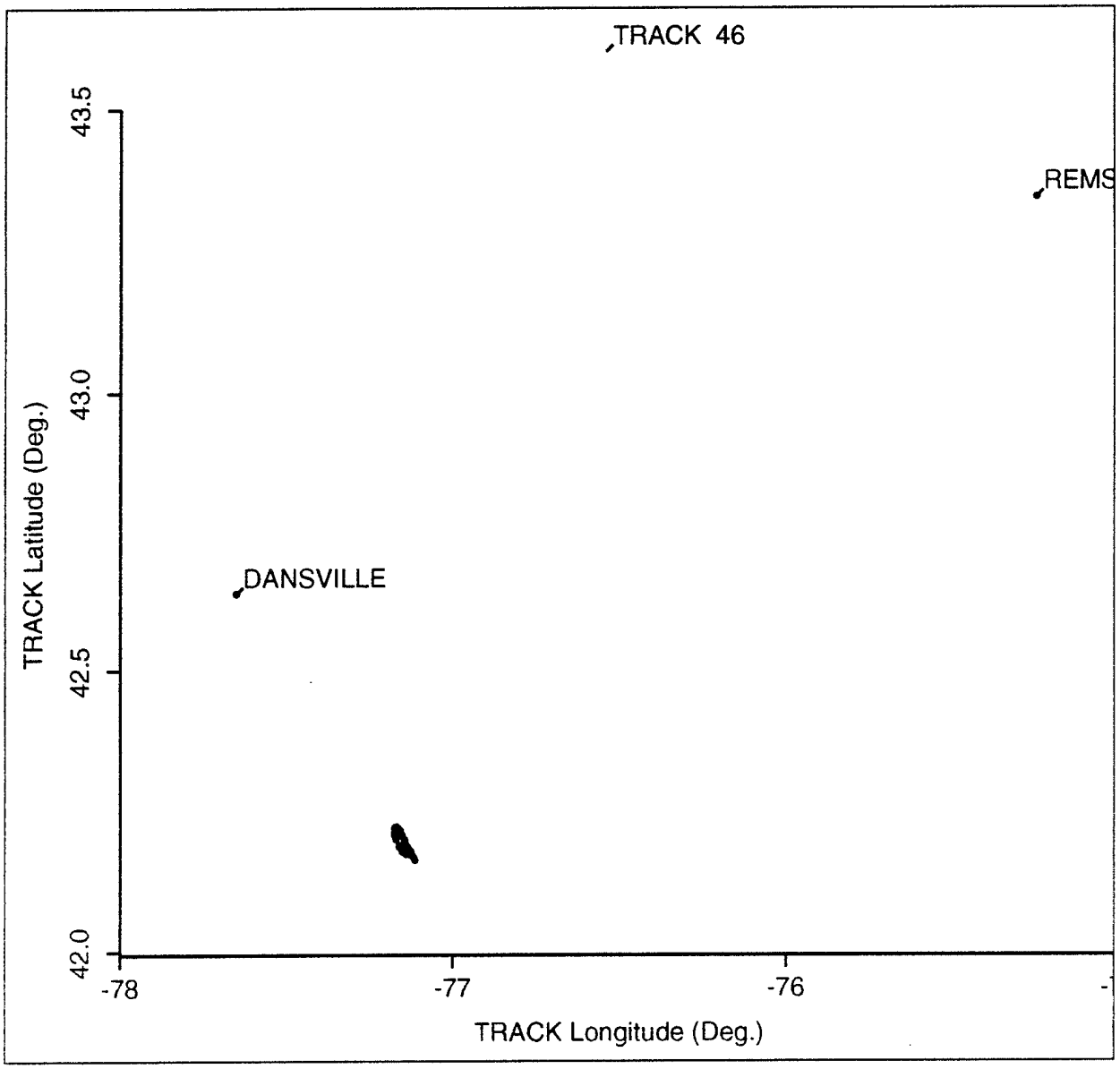


Figure 5 - Fused Track #46

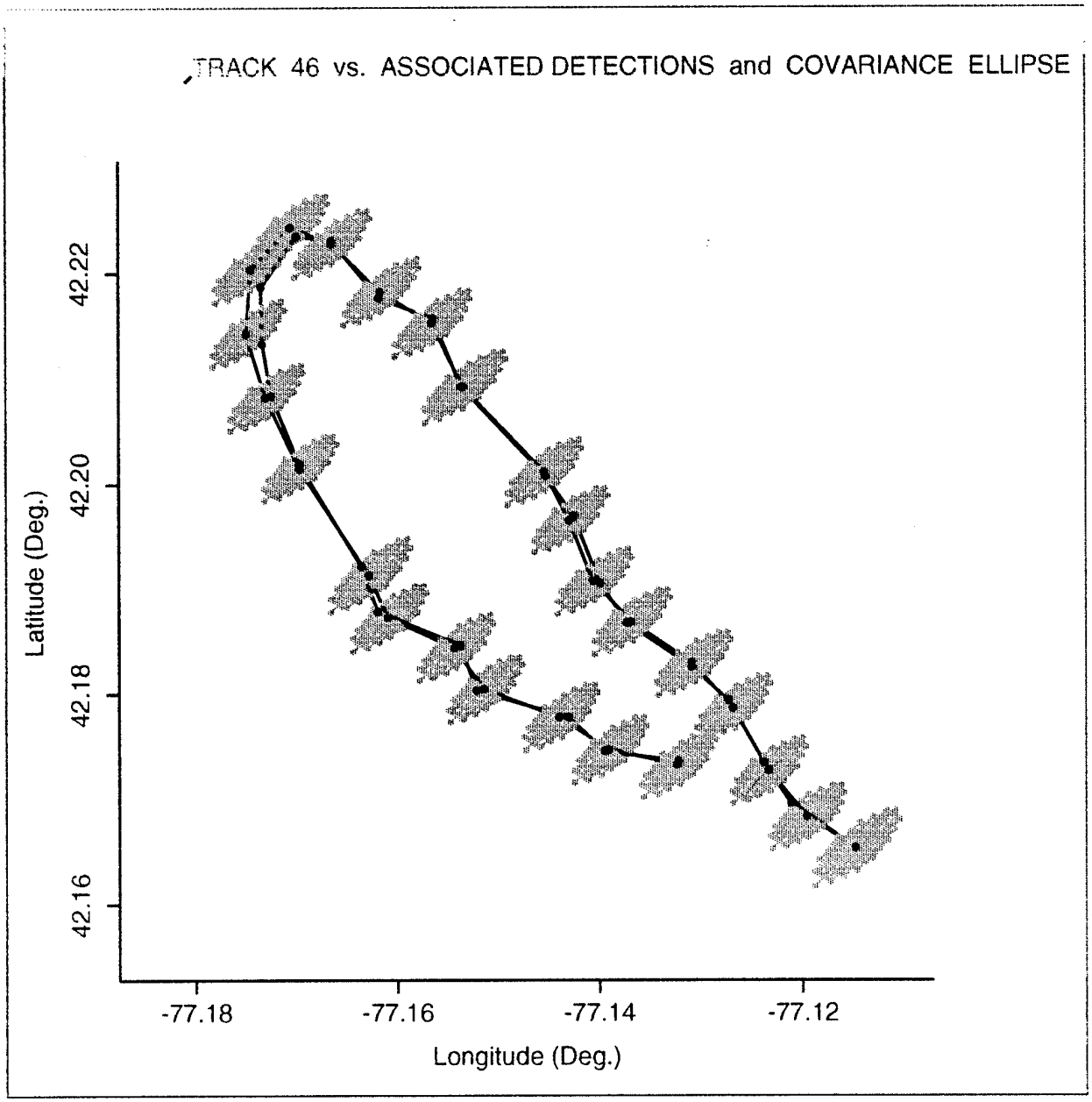


Figure 6 - Track #46 Detections, Track, & Variance Ellipse

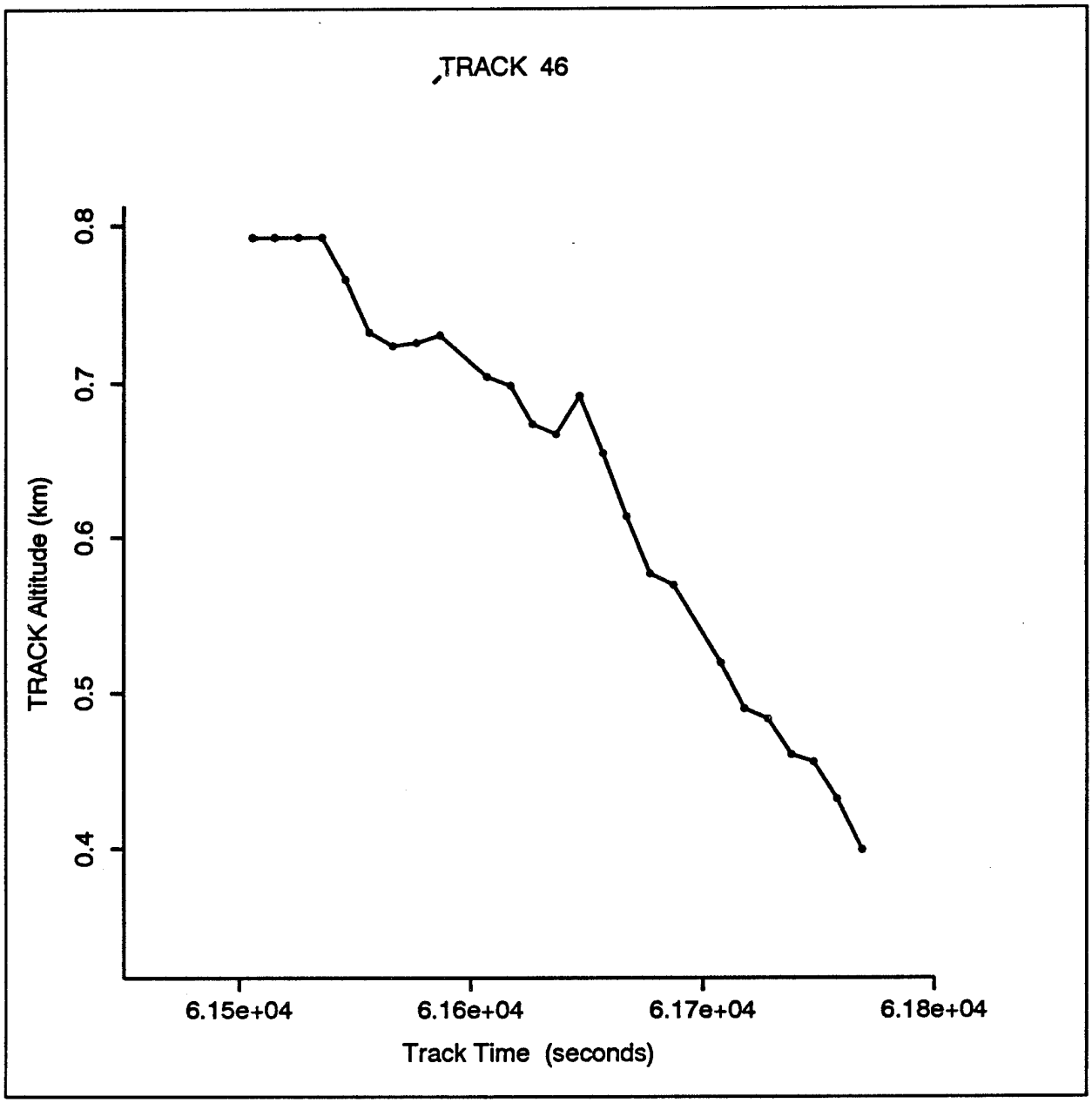


Figure 7 - Track #46, Altitude Plot

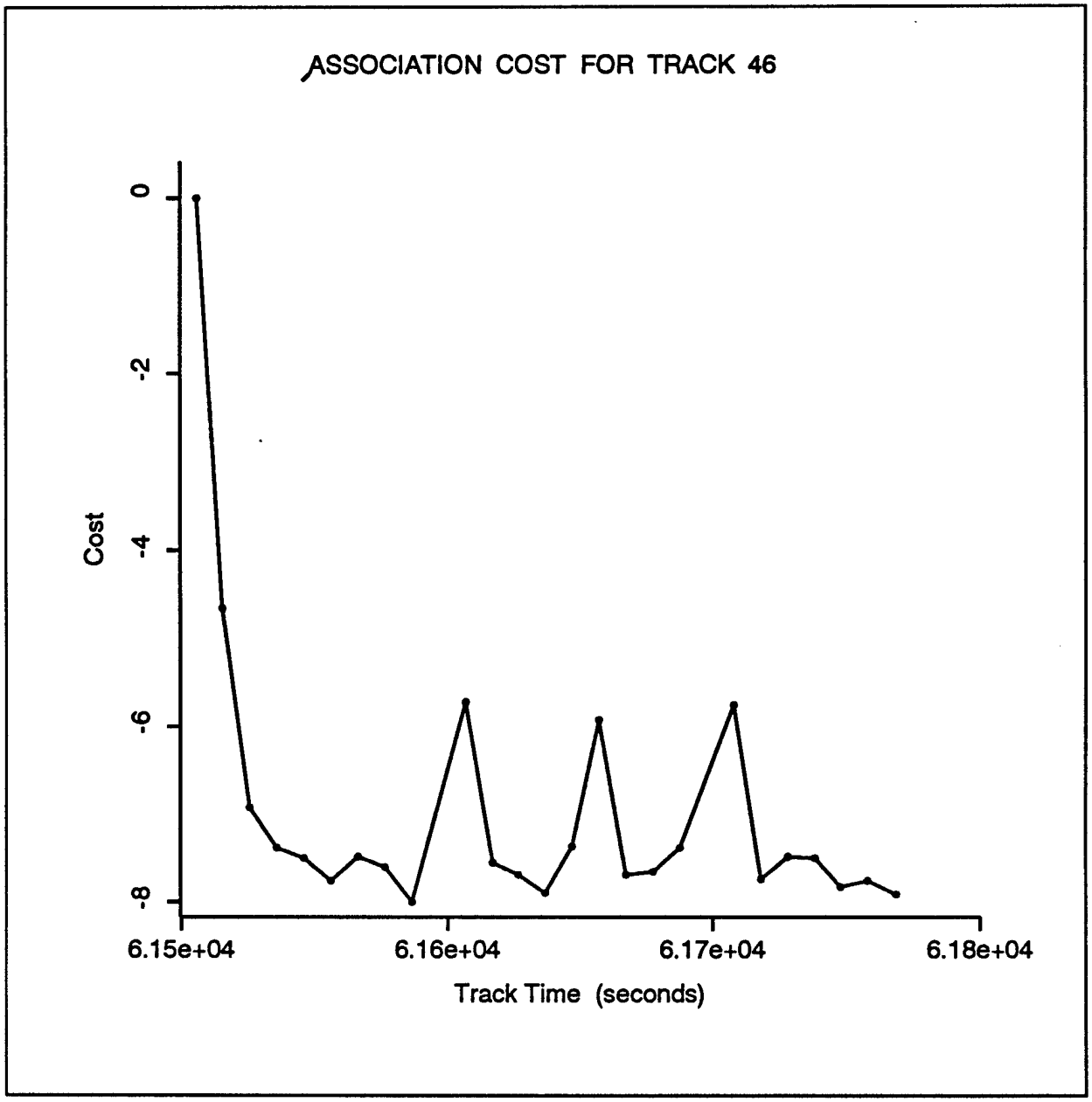


Figure 8 - Detection to Track Association Cost (Neg-Log-Liklihood)

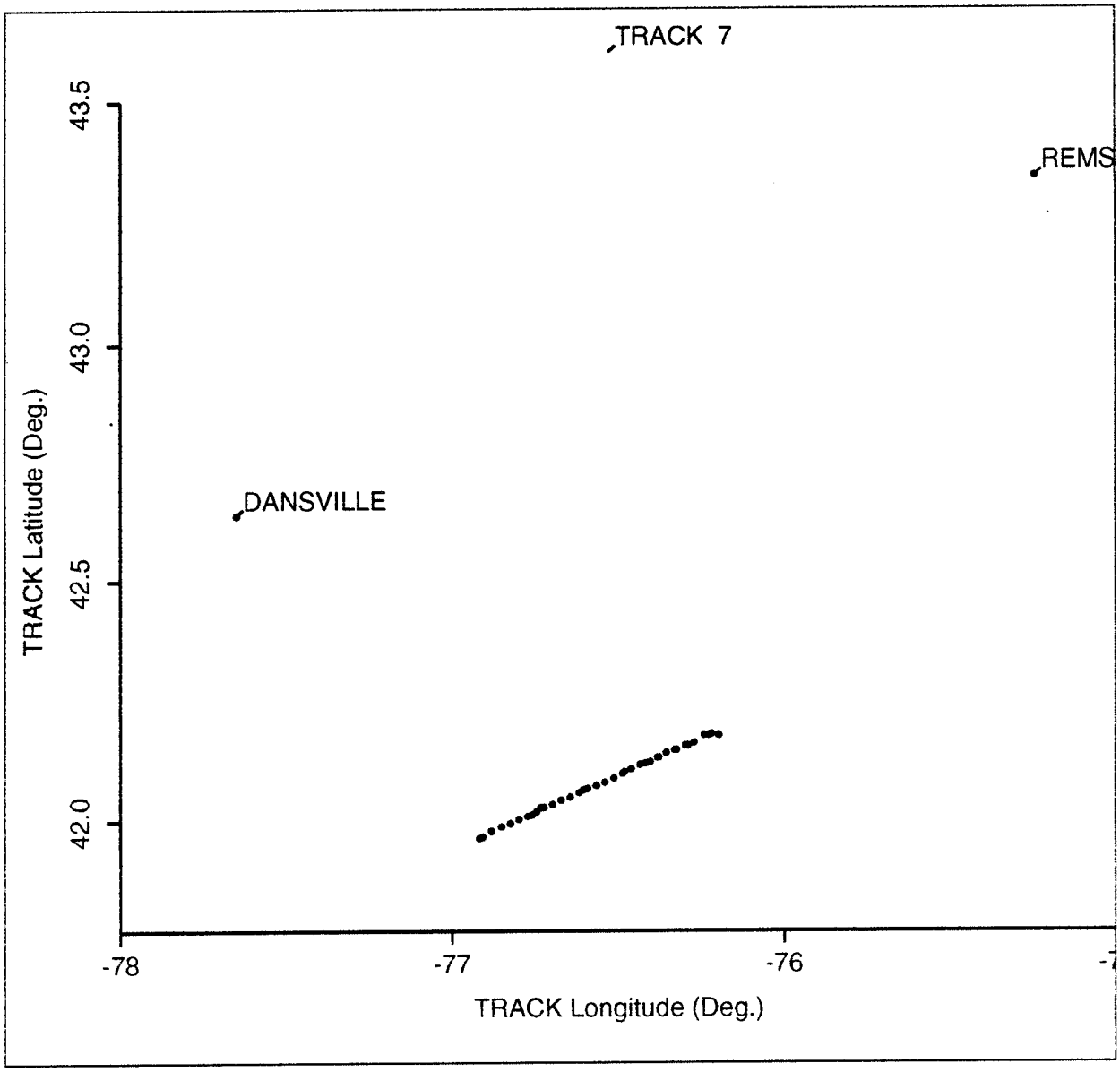


Figure 9 - Track 7

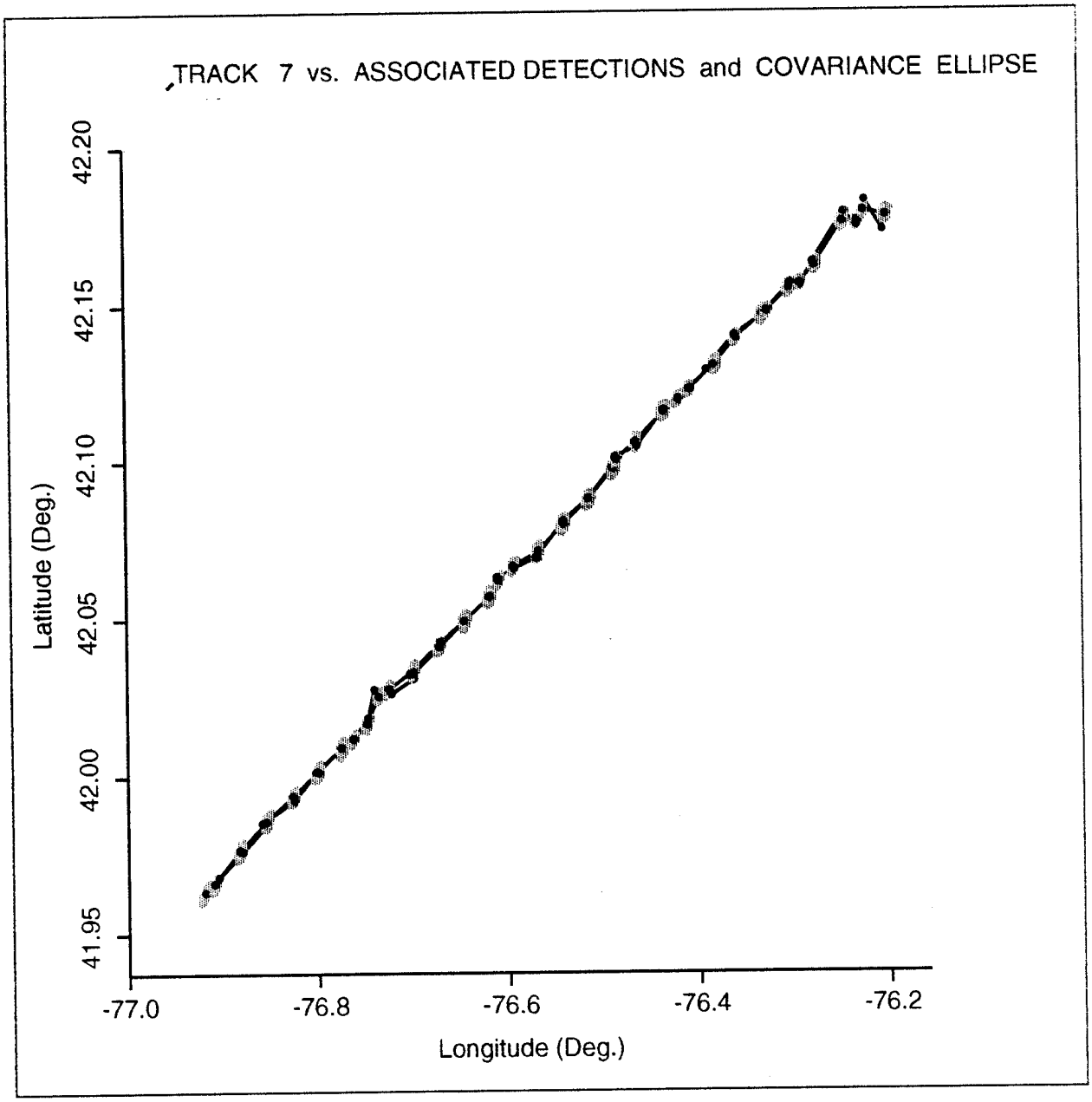


Figure 10 - Track 7 Detections Track, & Covariance Ellipse

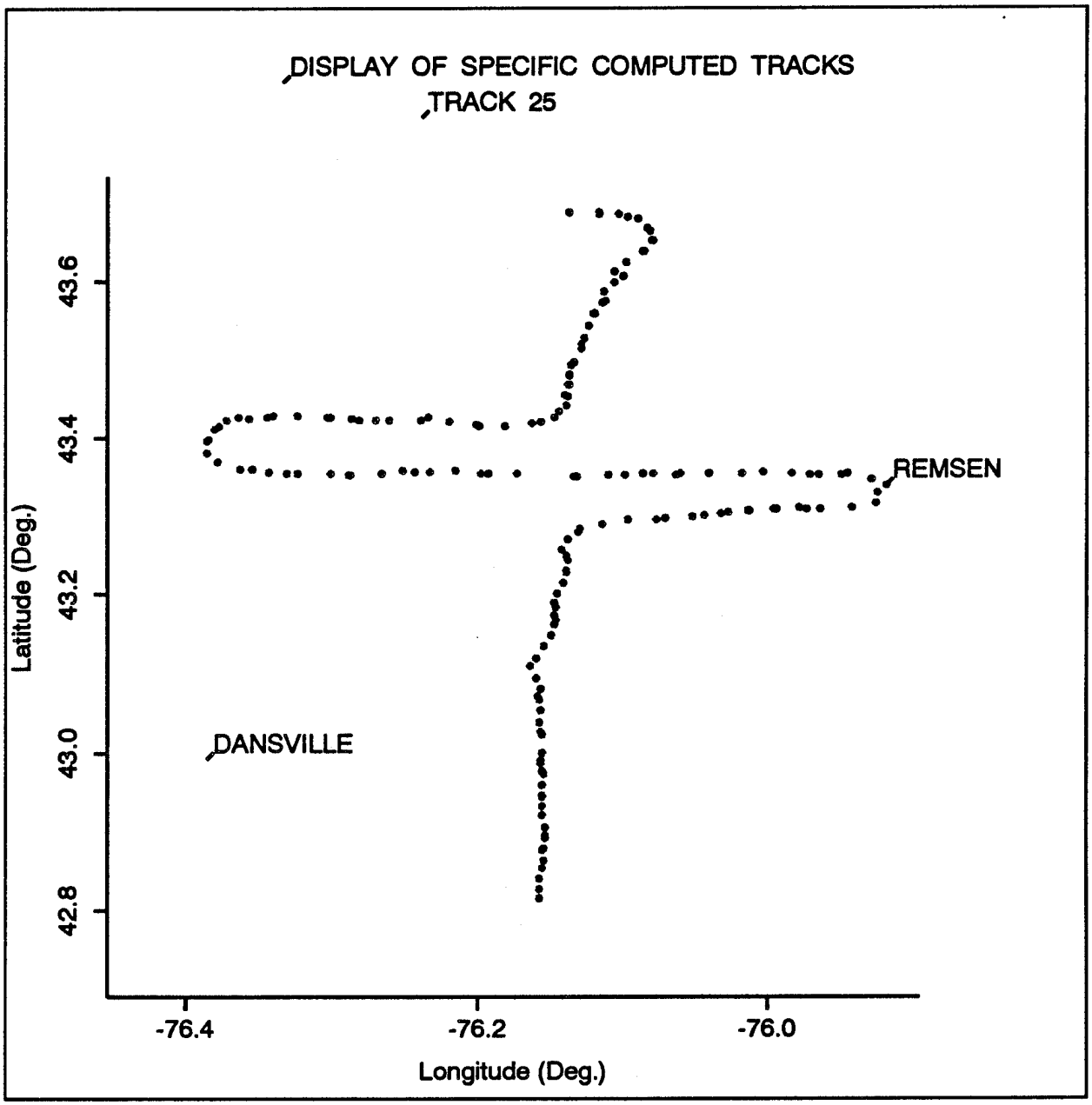


Figure 11 - S-Turn

Table 1
OCSM Fusion Testbed Operational Instructions Check List

Example Access:
Remote Access Over Local Network using UNIX Workstation

Step #	Action	Result
---------- Setup Testbed Run Session to include a Graphic Display Capability		
1	Open UNIX shell and telnet to JACOB	Receive login prompt
2	login to the MIST account, give password	user is at MIST working directory
3	set the DISPLAY environment to the workstation network address so that display graphics are displayed on the remote screen. setenv DISPLAY amdfindi:0	none
--------- Setup a file editing session that allows the use of an x windows file editor --- "x-edit"		
1	Open UNIX shell and telnet to JACOB	Receive login prompt
2	login to the MIST account, give password	user is at MIST working directory
3	set the DISPLAY environment to the workstation network address so that display graphics are displayed on the remote screen. setenv DISPLAY amdfindi:0	none
4	entering --- xedit config/"filename" & will start an x-windows text editor that will allow the operator to edit the testbed configuration files contained in the configuration sub-directory.	
5	edit the configuration files as appropriate for the test desired. Save the files.	
6	return to the first shell and enter the tracker run command: "tracker4 -f Type1_Tracker.config"	The display object selected will appear displaying the detections and tracks developed during this a graphic window fusion run.

4.0 Future Efforts

While working on this project a number of future efforts have been identified. We wish to take this time to list these efforts in order to serve as a starting point for discussions and planning.

Effort List

1. Increase the fidelity of the surveillance target simulation capability.
   a. Measured data cloning.
   b. Threat engagement and Sensor modeling.

2. Using the results of 1, develop baseline stressing test cases.

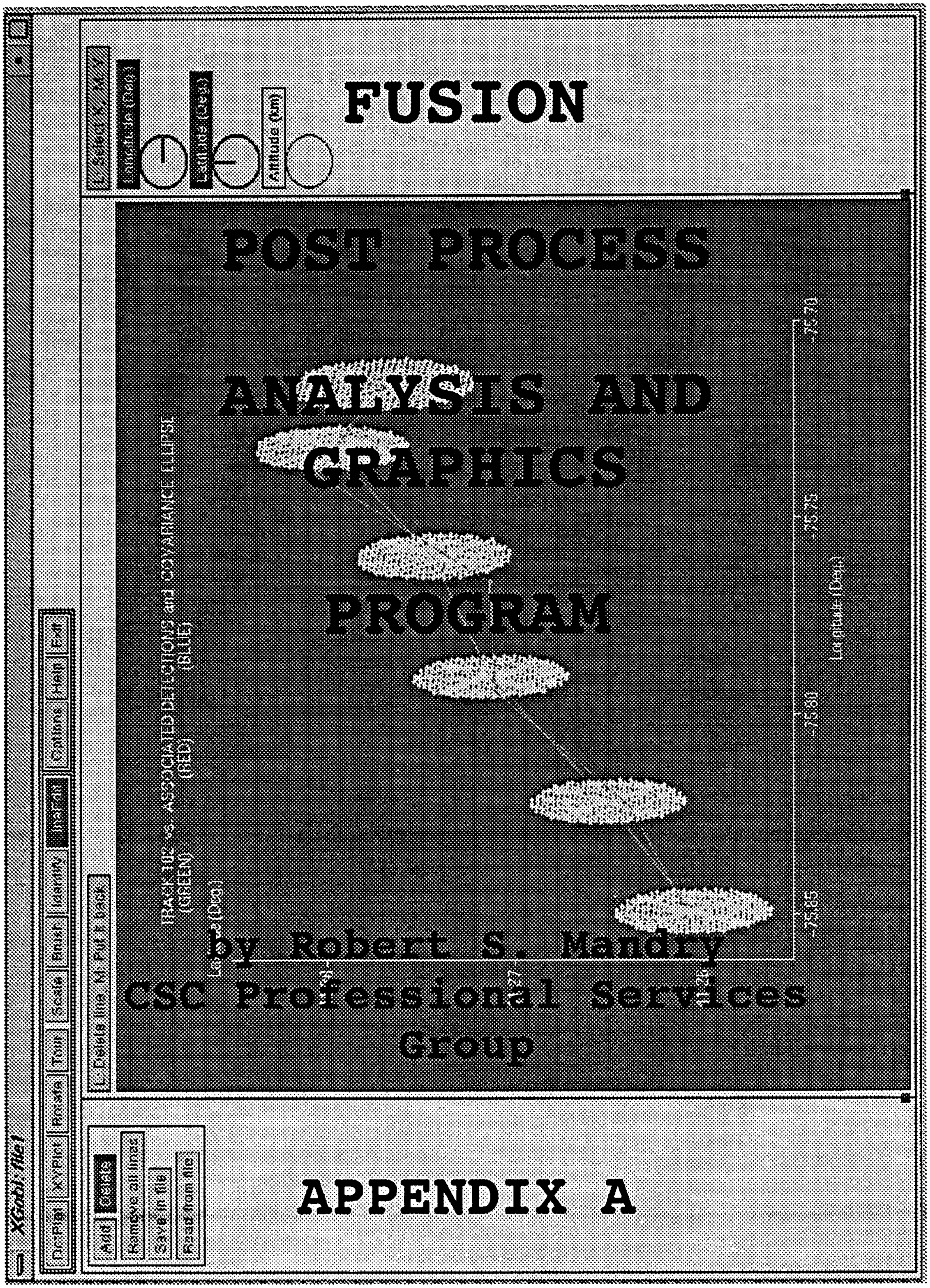
3. Evaluate the need, requirements and approach to develop a "networked" processing capability. Early planning may eliminate later modifications to the testbed.

References

[1] Yeddanapudi, M., Y. Bar-Shalom, K.R. Pattipatti, T. Kirubarajan, and S. Deb, "MATSurv: Multisensor Air Traffic Surveillance", Rome Lab Progress Report, April 26, 1994, pp. 1-36.

[2] Robert L. Popp, "Multisensor-Multitarget Data Fusion using an S-Dimensional Sliding Window Assignment Algorithm" , Rome Laboratory Graduate Student Research Program Final Report, September 1994, pp. 1-20

[3] CSC Professional Services Group, "Innovative Approach to the Development of a Variable Configuration Multisensor Test Capability", Rome Laboratory Final Report, October 1994, pp. 1-30



FUSION

POST PROCESS

ANALYSIS AND GRAPHICS

PROGRAM

by Robert S. Mandry
CSC Professional Services Group

APPENDIX A

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INTRODUCTION

This document has been put together to illustrate the current state and capabilities of the **fusion post-processing** code. On the following pages, each capability has been explained in words, via User interaction, and in terms of outputs.

The **fusion post-processing** code is currently comprised of a main C program which may invoke any of a number of C subroutines to perform any necessary mathematical processing and then creates a number of data sets needed by the shareware plotting package **XGobi**. The manual for **XGobi** will be provided under separate cover.

Prior to the running of the **fusion post-processing** code, the data to be analyzed must be created by the particular algorithm being used. This is accomplished by using subroutines generated by CSC which dump the pertinent data into files to be then read in by the post-processing code. Before calls to these subroutines are inserted into the Algorithm at positions where tracks are being initiated and propagated, the variable names corresponding to the following data needs to be identified (**if this data does not exist for a particular Algorithm or group of scans** (such as Target ID), then it <u>does not need to be output</u> to the file):

INPUT DATA

```
The RAW Detection Data Set Column HEADINGS ARE:
  0)  Time (seconds)
  1)  Scan Number
  2)  Detect # In Scan
  3)  Sensor ID
  4)  Detect Longitude (Deg.)
  5)  Detect Latitude (Deg.)
  6)  Detection Altitude (km)
  7)  Target ID
```

DESCRIPTION

0)	Time (seconds)	Time of Detection in Scan
1)	Scan Number	Scan Number
2)	Detect # In Scan	Detect # In Scan
3)	Sensor ID	Sensor Identification (could be ASCII or numerical)
4)	Detect Longitude (Deg.)	Detection Location (**Units** according to Algorithm in question)
5)	Detect Latitude (Deg.)	
6)	Detection Altitude (km)	
7)	Target ID	Target Identification (Input with Scan)

COMPUTED DATA

The COMPUTED Data Set Column HEADINGS ARE:

0) Track Time (seconds)
1) Track Number
2) Scan Number
3) Detect # In Scan
4) LatestAssoc.Detect Long.
5) LatestAssoc.Detect Lat.
6) LatestAssoc.Detect Alt.
7) TRACK Longitude (Deg.)
8) TRACK Latitude (Deg.)
9) TRACK Altitude (km)
10) Vel. Due North (km/s)
11) Vel. Due East (km/s)
12) Vertical Vel. Up (km/s)
13) Velocity Magnitude
14) Cost
15) Target ID
16) TRACK Cov. dueNorth (km)
17) TRACK Cov. due East (km)
18) TRACK Cov. up (km)
19) TRACK Cov. NE (km)
20) TRACK Cov. N UP (km)
21) TRACK Cov. E UP (km)

DESCRIPTION

0)	Track Time (seconds)	Time of Detection in Scan
1)	Track Number	Algorithm Calculated Track No.
2)	Scan Number	Scan Number
3)	Detect # In Scan	Detect # In Scan
4)	LatestAssoc.Detect Long.	Detection Location (**Units** according to Algorithm in question) Associated with this Track Point.
5)	LatestAssoc.Detect Lat.	
6)	LatestAssoc.Detect Alt.	
7)	TRACK Longitude (Deg.)	Track Point Location (**Units** according to Algorithm in question).
8)	TRACK Latitude (Deg.)	
9)	TRACK Altitude (km)	
10)	Vel. Due North (km/s)	Velocity Vector and CSC computed Velocity Magnitude.
11)	Vel. Due East (km/s)	
12)	Vertical Vel. Up (km/s)	
13)	Velocity Magnitude	
14)	Cost	Cost of Target Association
15)	Target ID	Target Identification (Input with Scan)
		Track Covariance Matrix Terms:
16)	TRACK Cov. dueNorth (km)	Position (1,1)
17)	TRACK Cov. due East (km)	Position (2,2)
18)	TRACK Cov. up (km)	Position (3,3)
19)	TRACK Cov. NE (km)	Position (1,2)
20)	TRACK Cov. N UP (km)	Position (1,3)
21)	TRACK Cov. E UP (km)	Position (2,3)

SCAN DATA MENU

MENU APPEARANCE IN SHELL:

```
SCAN DATA MENU:
  1.  TABULAR Display of Scan Number, Location, # of Detects, Time Interval
  2.  TABULAR Display of Target ID (IFF)  and  Number of Detects per ID
  3.  PLOT ALL SCANS (time, lat, long, alt.)
  4.  SCAN PLOT of (time, lat, long, alt.) data
  5.  TARGET ID PLOT of (time, lat, long, alt.) data
  6.  TRANSFER To Track Data MENU
  7.  QUIT
```

COMPUTED DATA MENU

MENU APPEARANCE IN SHELL:

```
Track Data MENU 2:
  0.  PLOT Tracks
  1.  Output Tables by Track Numbers containing Number of Associated Detections and:
      a.  Minimum time and Maximum time
      b.  Range of Track Coordinates
  2.  PLOT One Track
  3.  PLOT One Track and Associated Detections
  4.  PLOT Association Cost
  5.  COMPUTE TABULAR Summary of Innovation (Detections - Track) along with corresponding plot.
  6.  OUTPUT a Table of Target ID vs. Associated Tracks
  7.  PLOT Track Covariances vs. Time
  8.  PLOT Covariance Ellipses for Detections vs. Tracks
  9.  PRINT OUT (by time tick) Selected Data Corresponding to a Particular Track
 10.  PLOT ALL Track Points Corresponding to a Particular Target ID
 11.  PLOT Velocity by Track
 12.  TRANSFER to Scan Data Menu
 13.  QUIT
MENU Choice:
```

VARIABLE DEFINITION

After invoking the program, the following menu is displayed:

```
Choose the DATA to be Examined:
   1.  SCAN Data
   2.  Track Data
   3.  QUIT

DATA CHOICE:  1
```

Figure 1

The next several displays allow the user to identify which columns in his/her data set correspond to the variable descriptions needed for the TABLE outputs and PLOTS created by the program. Three types of inputs are possible:

1. A **single integer** INPUT names one column. (**Figure 2**)

2. **Three integer inputs** correspond usually to location, either (Longitude, Latitude, and Altitude) or (X,Y,Z). (**Figure 3**)

3. If a **variable does not exist in the data set**, the User should INPUT a -1. (**Figure 4**)

```
The RAW Detection Data Set Column HEADINGS ARE:
  0)  Time (seconds)
  1)  Scan Number
  2)  Detect # In Scan
  3)  Sensor ID
  4)  Detect Longitude (Deg.)
  5)  Detect Latitude (Deg.)
  6)  Detection Altitude (km)
  7)  Target ID

    The variable(s) to be identified:  Detection Time


                [There should be 1 integer inputs.]

[Choose the column number from the above list which corresponds to the above named variable(s).]
        [INPUT a -1 if there is no data which corresponds to this variable(s).]
0
```

Figure 2

VARIABLE DEFINITION Continued

```
The RAW Detection Data Set Column HEADINGS ARE:
  0)  Time (seconds)
  1)  Scan Number
  2)  Detect # In Scan
  3)  Sensor ID
  4)  Detect Longitude (Deg.)
  5)  Detect Latitude (Deg.)
  6)  Detection Altitude (km)
  7)  Target ID

     The variable(s) to be identified:  Detection Location


                [There should be 3 integer inputs.]

[Choose the column number from the above list which corresponds to the above named variable(s).]
        [INPUT a -1 if there is no data which corresponds to this variable(s).]
4 5 6
```

Figure 3

```
The RAW Detection Data Set Column HEADINGS ARE:
  0)  Time (seconds)
  1)  Scan Number
  2)  Detect # In Scan
  3)  Sensor ID
  4)  Detect Longitude (Deg.)
  5)  Detect Latitude (Deg.)
  6)  Detection Altitude (km)
  7)  Target ID

     The variable(s) to be identified:  Target ID


                [There should be 1 integer inputs.]

[Choose the column number from the above list which corresponds to the above named variable(s).]
        [INPUT a -1 if there is no data which corresponds to this variable(s).]
-1
```

Figure 4

UNITS DEFINITION, TIME "NORMALIZATION"

The next menu requests the User to **INPUT** the **Unit Choice** of his/her raw data (Scan or **Detections**) and measurement data (Algorithm calculated or **Track Calculations**) (**Figure 5**).

```
**************************************************
Unit Choice for Detections and Track Calculations:
  1.  Longitude (Deg.), Latitude (Deg.), Altitude (km)
  2.  (x,y,z) positions
INPUT Unit Choice:  1
```

Figure 5

The next menu (**Figure 6**) is referred to as the

Time NORMALIZATION MENU.

It allows the User to request that the data all be **NORMALIZED** to the **Earliest Detection Time of All Scans.** Since data occasionally enters the Algorithm as actual flight time, the time values plotted may turn out to be expressed in exponential notation and the User may not gain a true feel for the range of data being plotted. Choosing *Option 2* from **Figure 6** allows the User to use as the "0.0 second" reference point the earliest detection time of all the detections which results in plots with smaller, and more easily readable, values for the Time Axis of the given plot.

If *Option 2* from this MENU is chosen, then an additional subtitle is added to the plot which identifies the time value used in the **NORMALIZATION** process. This is the value which has been subtracted from **each** of the time values shown in the plot.

In this document, if a time axis is plotted, then both in many cases UN-NORMALIZED and NORMALIZED plots will be shown. The NORMALIZED plot will always be on the next page after the UN-NORMALIZED plot and will have the Figure Number **Figure *(normalized).**

```
Time NORMALIZATION MENU:
  1.  Use UN-NORMALIZED Times as Listed in Input File
  2.  NORMALIZE Times to Earliest Detection Time of All Scans

Time NORMALIZATION CHOICE:  2
```

Figure 6

Missing Variables ERROR Example

Before proceeding through the *Options*, one additional feature will be described. If the User does not have data in his/her data set which corresponds to a particular plotting capability, a "-1" should be INPUT (**Figure 4**). When a plot is requested which uses the missing data (**Figure 7**), then the error message of **Figure 8** will be displayed and the User will be rerouted to the MENU that he/she was last working with.

```
SCAN DATA MENU:
  1.  TABULAR Display of Scan Number, Location, # of Detects, Time Interval
  2.  TABULAR Display of Target ID (IFF)  and  Number of Detects per ID
  3.  PLOT ALL SCANS (time, lat, long, alt.)
  4.  SCAN PLOT of (time, lat, long, alt.) data
  5.  TARGET ID PLOT of (time, lat, long, alt.) data
  6.  TRANSFER To Track Data MENU
  7.  QUIT

SCAN DATA plot CHOICE:  5
```

Figure 7

```
The variables needed for the chosen procedure are:
     Detection Time, Target ID, Detection Location [2 to 4]

In the above list, Variable #1 is missing from the INPUT data set.
         [Variable count begins with 0]
************************************************************
************************************************************
************************************************************

Please choose ANOTHER Option:

************************************************************

SCAN DATA MENU:
  1.  TABULAR Display of Scan Number, Location, # of Detects, Time Interval
  2.  TABULAR Display of Target ID (IFF)  and  Number of Detects per ID
  3.  PLOT ALL SCANS (time, lat, long, alt.)
  4.  SCAN PLOT of (time, lat, long, alt.) data
  5.  TARGET ID PLOT of (time, lat, long, alt.) data
  6.  TRANSFER To Track Data MENU
  7.  QUIT

SCAN DATA plot CHOICE:
```

Figure 8

SCAN DATA MENU: *Option 1*

```
SCAN DATA MENU:
  1.  TABULAR Display of Scan Number, Location, # of Detects, Time Interval
  2.  TABULAR Display of Target ID (IFF)  and  Number of Detects per ID
  3.  PLOT ALL SCANS (time, lat, long, alt.)
  4.  SCAN PLOT of (time, lat, long, alt.) data
  5.  TARGET ID PLOT of (time, lat, long, alt.) data
  6.  TRANSFER To Track Data MENU
  7.  QUIT

SCAN DATA plot CHOICE:  1
```

Figure 9

The first *Option* displayed is

1. TABULAR Display of Scan Number, Location, # of Detects, Time Interval

This *Option* will yield a display to the User's shell comprised of five columns (**Figure 12** on the next page):

1. Scan Number (as in the Input data set)
2. Location (This example - Remsen (R) or Dansville (D))
3. # of Associated Detects for that Scan
4. Minimum Time (in Scan)
5. Maximum Time (in Scan)

Once this display is made to the shell, the query of **Figure 10** will be made to the User to obtain a **HARD COPY** of the Table on the laser printer. By **entering the number "1"**, a **HARD COPY** may be obtained. If the User responds **"2"** (for "NO") or **pushes <Enter> twice**, then the **HARD COPY** is **skipped** and the menu of **Figure 13** will be offered to the User (page A-8).

[**If the User responds with an incorrect answer** to the query of **Figure 10**, then the "comment" of **Figure 11** will be displayed on the User's shell and the query of **Figure 10** will be posed again.]

```
**********************************************************
Do you want to have a HARD COPY of the above TABLE?
     1)  YES
     2)  NO  [or push <Enter> TWO TIMES]
3
```

Figure 10

```
**********************************************************
ERROR in Data INPUT:
    INPUTTED Value:  3
[1 or 2 or  <Enter> TWO TIMES  are the only acceptable values.]
     Please Try AGAIN.
**********************************************************
```

Figure 11

SCAN DATA MENU: *Option 1* Continued

Scan Number	Sensor	# of Detects	Minimum Time	Maximum Time
1	R	29	61499.898	61508.102
2		0		
3	D	33	61501.699	61505.500
4	R	37	61511.102	61517.500
5	D	36	61511.898	61515.500
6	D	33	61521.602	61525.801
7	R	31	61523.199	61532.500
8	D	34	61531.801	61535.801
9	R	30	61535.102	61542.602
11	R	35	61547.301	61554.500
12	D	40	61552.199	61556.199
13	R	35	61559.602	61564.801
14	D	39	61562.199	61566.199
15	R	34	61571.102	61577.301
16	D	34	61572.301	61576.102
17	D	33	61582.398	61586.398
18	R	34	61583.398	61589.199
19	D	37	61592.602	61596.398
20	R	29	61595.199	61604.102
21	D	40	61602.602	61606.699
22	R	29	61607.398	61616.301
23	D	40	61612.801	61616.801
24	R	31	61619.398	61625.301
25	D	40	61622.602	61626.699
26	R	32	61631.301	61637.199
27	D	43	61632.801	61636.898
28	R	29	61643.301	61649.000
29	D	37	61642.898	61646.898
30		0		
31	D	36	61653.000	61657.102
32	R	28	61655.602	61661.102
33	D	27	61663.199	61667.199
34	R	28	61667.500	61675.000
35	D	37	61673.500	61677.398
36	R	28	61679.699	61686.898
37	D	37	61683.398	61687.602
38	R	34	61691.699	61697.801
39	D	34	61693.500	61697.500
40	D	33	61703.898	61707.602
41	R	32	61704.398	61709.699
42	D	27	61713.699	61717.602
43	R	26	61715.500	61721.898
44	D	31	61723.801	61727.898
45	R	33	61727.699	61735.000
46	D	36	61733.898	61738.000
47	R	26	61739.602	61745.199
48	D	37	61744.199	61747.898
49	R	22	61752.000	61757.301
50	D	40	61754.199	61758.102
51		0		
52	R	35	61763.699	61769.699
53	D	40	61764.301	61768.301
54	D	35	61774.398	61778.500
55	R	32	61775.500	61784.500

Figure 12

SCAN DATA MENU: *Option 1* Continued

Scan Number	Sensor	# of Detects	Minimum Time	Maximum Time
1	R	29	0.000	8.203
2		0		
3	D	33	1.801	5.602
4	R	37	11.203	17.602
5	D	36	12.000	15.602
6	D	33	21.703	25.902
7	R	31	23.301	32.602
8	D	34	31.902	35.902
9	R	30	35.203	42.703
11	R	35	47.402	54.602
12	D	40	52.301	56.301
13	R	35	59.703	64.902
14	D	39	62.301	66.301
15	R	34	71.203	77.402
16	D	34	72.402	76.203
17	D	33	82.500	86.500
18	R	34	83.500	89.301
19	D	37	92.703	96.500
20	R	29	95.301	104.203
21	D	40	102.703	106.801
22	R	29	107.500	116.402
23	D	40	112.902	116.902
24	R	31	119.500	125.402
25	D	40	122.703	126.801
26	R	32	131.402	137.301
27	D	43	132.902	137.000
28	R	29	143.402	149.102
29	D	37	143.000	147.000
30		0		
31	D	36	153.102	157.203
32	R	28	155.703	161.203
33	D	27	163.301	167.301
34	R	28	167.602	175.102
35	D	37	173.602	177.500
36	R	28	179.801	187.000
37	D	37	183.500	187.703
38	R	34	191.801	197.902
39	D	34	193.602	197.602
40	D	33	204.000	207.703
41	R	32	204.500	209.801
42	D	27	213.801	217.703
43	R	26	215.602	222.000
44	D	31	223.902	228.000
45	R	33	227.801	235.102
46	D	36	234.000	238.102
47	R	26	239.703	245.301
48	D	37	244.301	248.000
49	R	22	252.102	257.402
50	D	40	254.301	258.203
51		0		
52	R	35	263.801	269.801
53	D	40	264.402	268.402
54	D	35	274.500	278.602
55	R	32	275.602	284.602

Figure 12(normalized)

SCAN DATA MENU: *Option 1* Continued

```
**************************************************
Do you want to have an X-Y PLOT of the above TABLE?
  [Scan Number vs. Number of Detects, by SENSOR]
     1)  Plot ALL SENSOR Data Together on ONE Plot
     2)  Plot EACH SENSOR's Data On a SEPARATE Plot
     3)  Continue On
1
```

Figure 13

Choice 1 from the menu of **Figure 13** is made which results in the display on the next page (**Figure 14**).

From this display, the **LineEdit** button is clicked. This will result in related points being connected by line segments (**Figure 15**).

To obtain the plot of **Figure 15** (page A-10) as the HARD COPY which has been inserted into this document, the **Options button** on the top panel of **Figure 14** is clicked on yielding the display of **Figure 16** (page A-11).

Next, the **Make postscript plot** of **Figure 16** button is clicked on yielding the display of **Figure 17** (page A-11). The User may choose from this display either

Write to file
OR
Send to printer.

SCAN DATA MENU: *Option 1* Continued

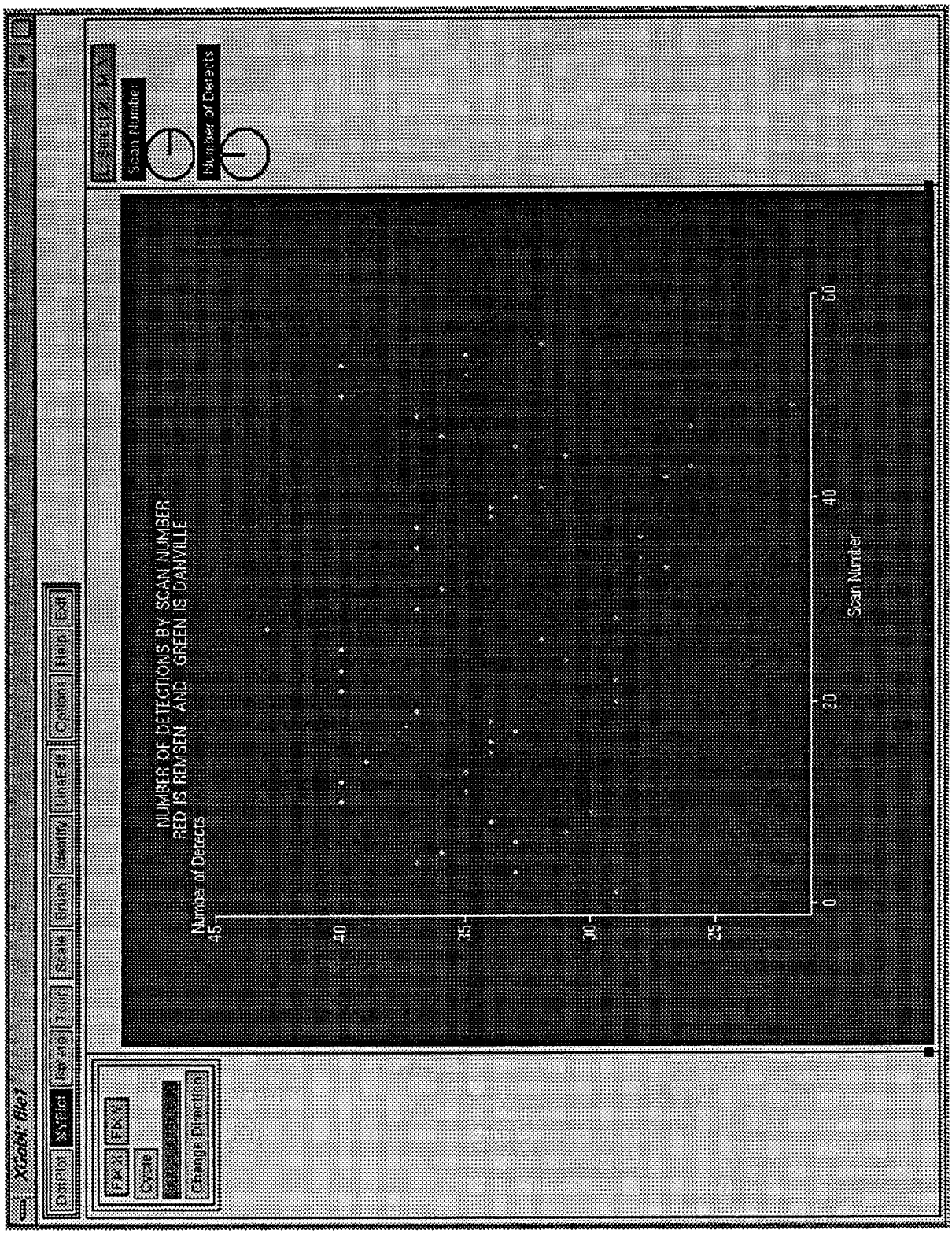


Figure 14

SCAN DATA MENU: *Option 1* Continued

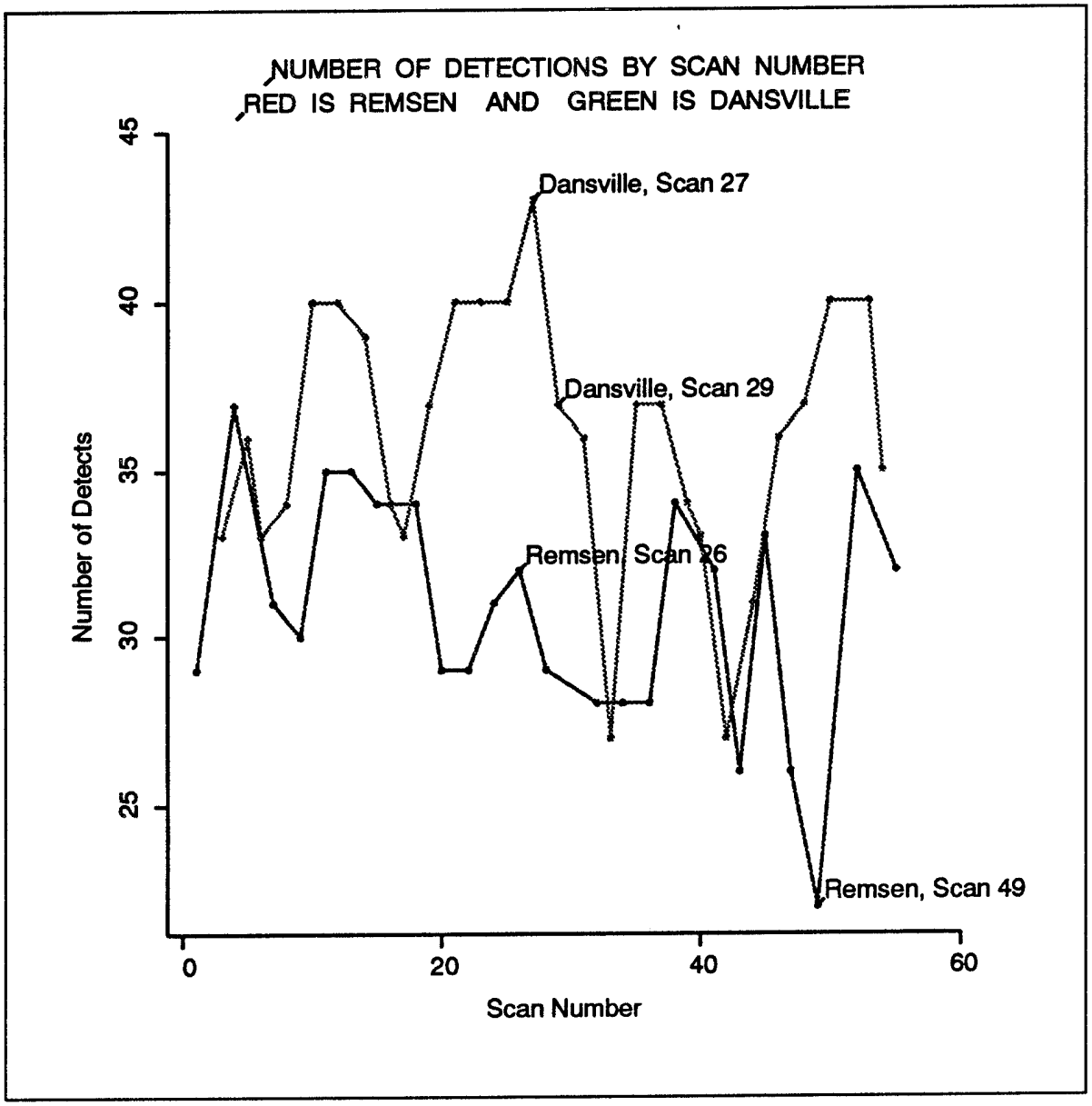
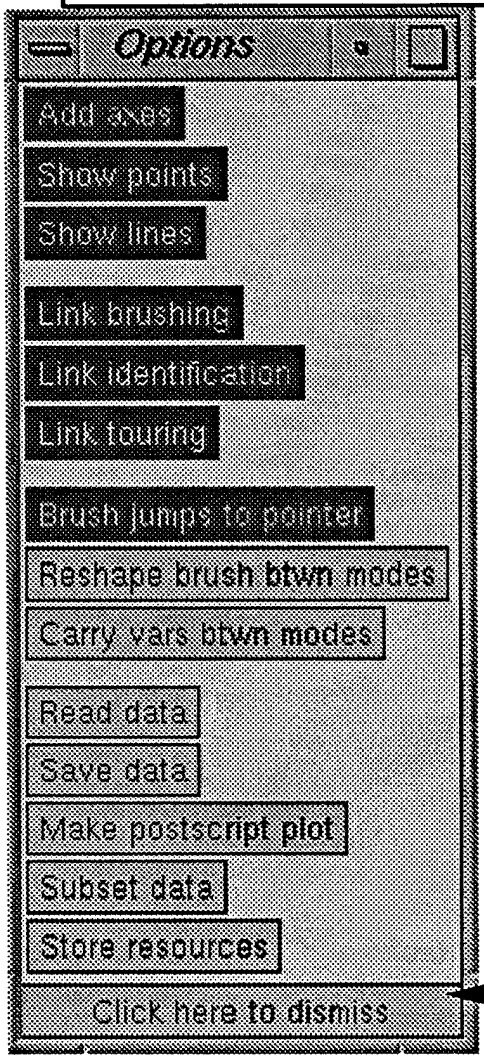


Figure 15

SCAN DATA MENU: *Option 1* Continued



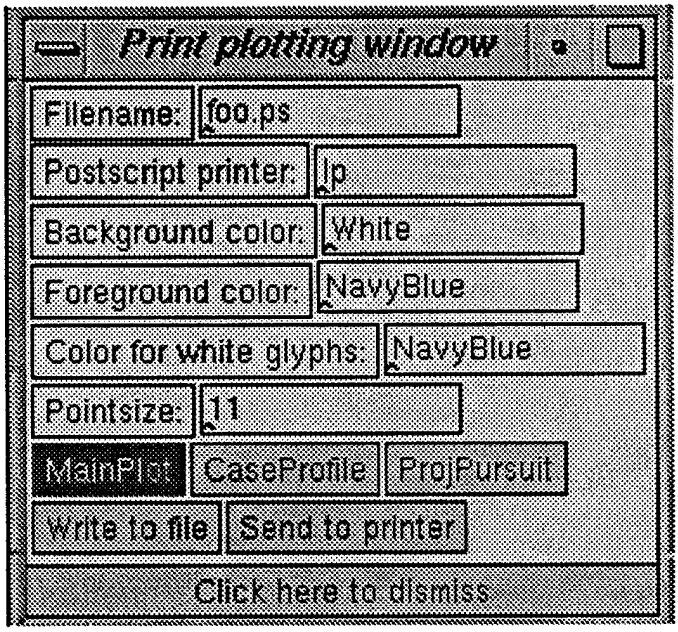


Figure 17

Figure 16

After clicking on the Exit button on the top panel of the XGobi graphics display (Figure 14 on page A-9), the menu of Figure 18 will reappear.

Choosing *Option 2* will result in the plots on the next page

(Figures 19 and 20)

being drawn one after the other.

Choosing *Option 3* will return the User to the SCAN DATA MENU

(Figure 21 on page A-13).

```
**************************************************
Do you want to have an X-Y PLOT of the above TABLE?
  [Scan Number vs. Number of Detects, by SENSOR]
     1)  Plot ALL SENSOR Data Together on ONE Plot
     2)  Plot EACH SENSOR's Data On a SEPARATE Plot
     3)  Continue On
2
```

Figure 18

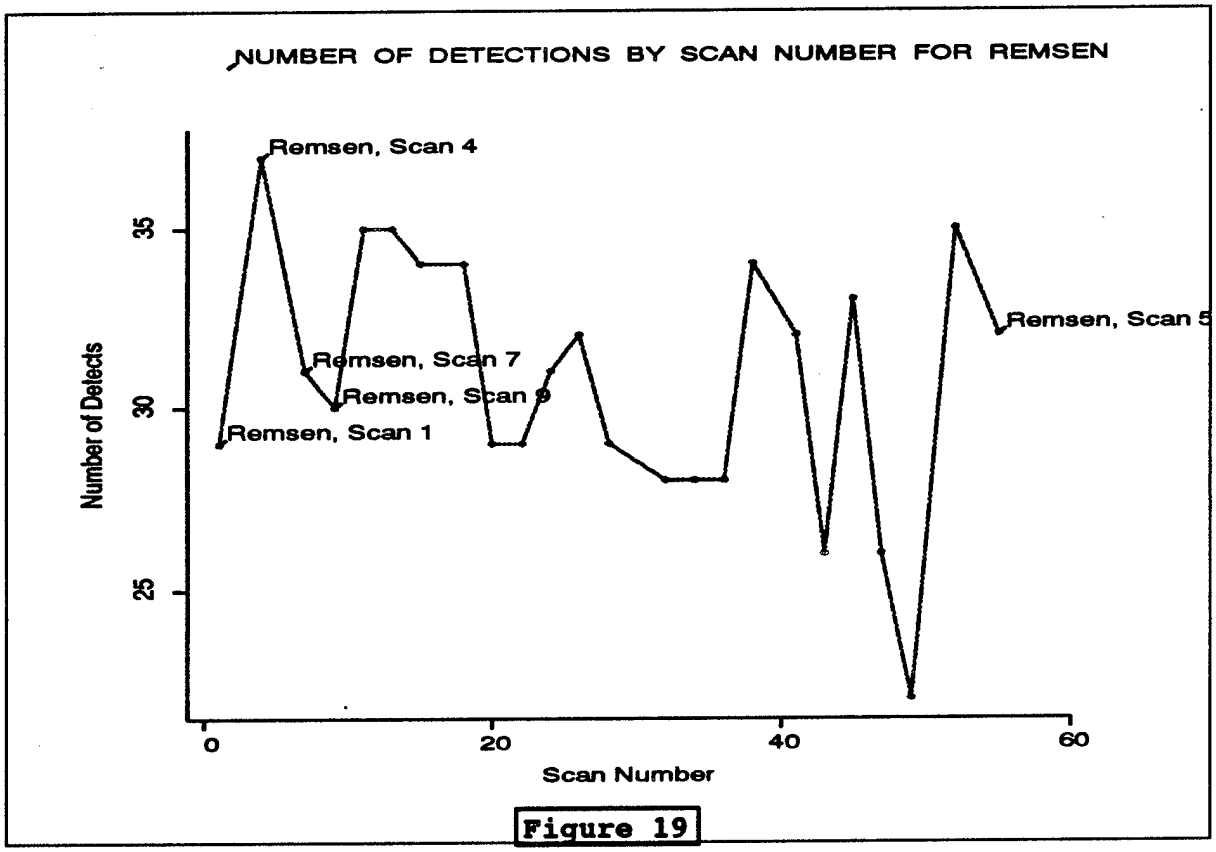


Figure 19

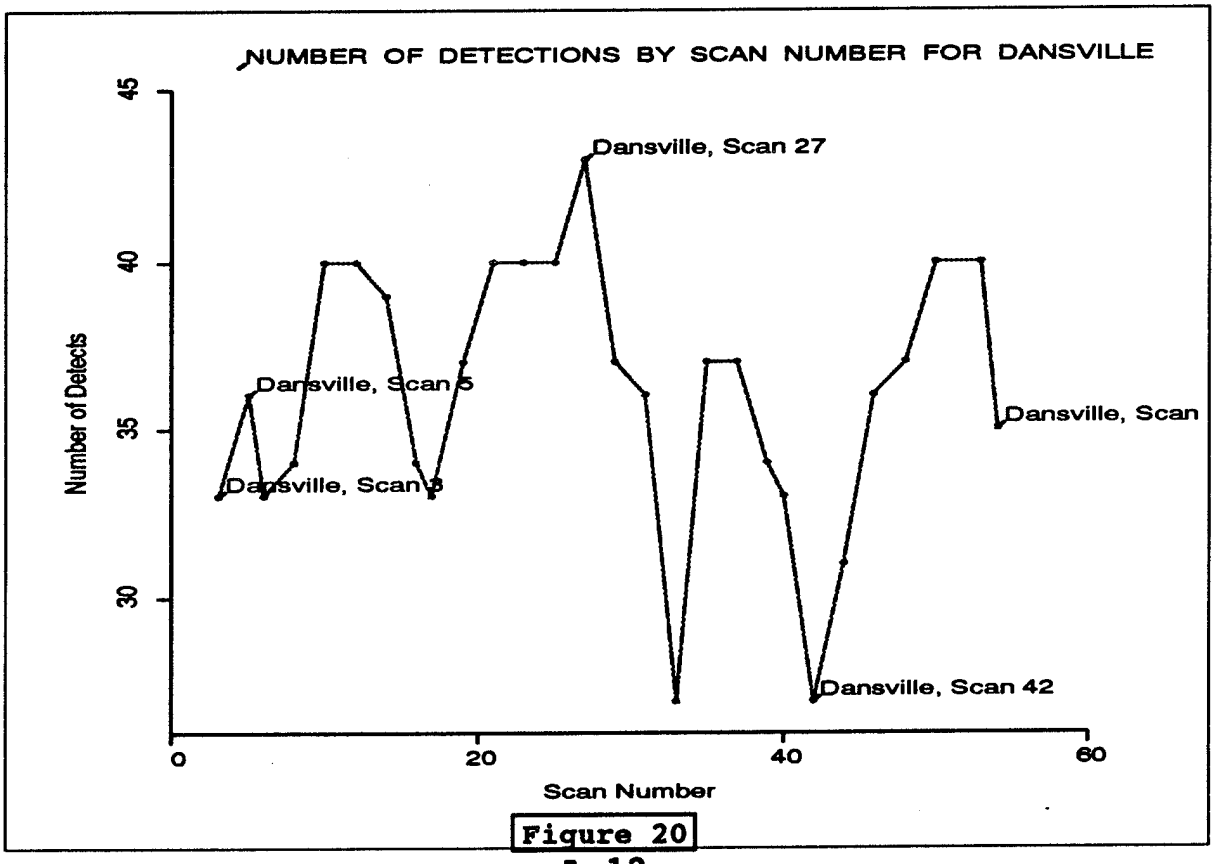


Figure 20

SCAN DATA MENU: *Option 2*

```
SCAN DATA MENU:
  1.  TABULAR Display of Scan Number, Location, # of Detects, Time Interval
  2.  TABULAR Display of Target ID (IFF) and Number of Detects per ID
  3.  PLOT ALL SCANS (time, lat, long, alt.)
  4.  SCAN PLOT of (time, lat, long, alt.) data
  5.  TARGET ID PLOT of (time, lat, long, alt.) data
  6.  TRANSFER To Track Data MENU
  7.  QUIT

SCAN DATA plot CHOICE:  2
```

Target ID (IFF)	Number of Detects
88	19
112	13
117	4
139	2
149	11
161	24
193	1
204	18
299	4
300	15
321	24
427	5
623	44
640	221
642	40
705	40
837	1
871	29
883	23
916	6
980	15
1058	33
1068	2
1073	37
1085	6
1162	2
1163	32
1164	35
1183	33
1215	1
1521	39
1530	3
1557	32
1692	11
1762	27
1764	1
1778	38
1800	25
1813	43
1895	35
1940	39
2059	43
2089	40
2109	2
2111	31
2127	15
2133	35
2142	12
2373	9
2438	11
2494	36
2805	15
2810	48
2891	25
2900	49
2931	11
3019	40
3050	2
3051	42
3089	33
3255	11
3478	43
3482	45
3501	24
3812	33
3877	26
3887	33

```
**************************************************
Do you want to have a HARD COPY of the above TABLE?
     1)  YES
     2)  NO
```

Choosing *Option 2* from the **SCAN DATA MENU** of **Figure 21** will yield the display of the **Table** of **Figure 22:**

Figure 22

SCAN DATA MENU: *Option 3*

```
SCAN DATA MENU:
  1.  TABULAR Display of Scan Number, Location, # of Detects, Time Interval
  2.  TABULAR Display of Target ID (IFF)  and  Number of Detects per ID
  3.  PLOT ALL SCANS (time, lat, long, alt.)
  4.  SCAN PLOT of (time, lat, long, alt.) data
  5.  TARGET ID PLOT of (time, lat, long, alt.) data
  6.  TRANSFER To Track Data MENU
  7.  QUIT
```

Figure 23

```
SCAN DATA plot CHOICE:  3
```

```
SENSOR Display Submenu:
  1.  PLOT Location of Dansville ONLY
  2.  PLOT Location of Remsen ONLY
  3.  PLOT Locations of ALL Sensors
  4.  DO NOT PLOT Location of Any Sensor

SENSOR Display Submenu Choice:  3
```

Figure 24

Option 3 from the **SCAN DATA MENU (Figure 23)** results in a plot of <u>all</u> Detections which were input into the Algorithm. Initially, *Option 3* will result in a plot of **Detect Longitude vs. Time.** Plotting **Sensor Location** is determined by the Submenu of **Figure 24.**

The display of **Figure 25** (page A-15) was obtained by <u>clicking the left mouse button on the circle below the words Detect Longitude (Deg.)</u> **and** <u>clicking the middle mouse button on the circle below the words Detect Latitude (Deg.)</u>.

The plotting window of this display has an Aspect Ratio of 1:1. The plot of the data was forced to correspond to this Aspect Ratio by adding two "dummy" points at the end of the data file which is being plotted. The sole purpose of these points is to scale the axes. In order to **UNDO this effect and "blow up" the plot** to correspond to only those data points originally requested by the User, a "cookbook procedure" is always written to the UNIX shell from which the code was initially invoked (**Figure 26** below). This procedure will be enumerated only once below but referred to later throughout this document.

```
**********************************************************
**********************************************************
In order to 'ZOOM IN' on the data (disregard the Aspect Ratio):
1.  Click on the 'Options' button.
2.  When the 'Options' menu appears, click on the 'Subset data' button.
3.  When the 'Subset data' menu appears, click on the 'Consec. block' button
    and subtract 2 from the 'to row' value for the 'Aspect Ratio' points
    and subtract 1 from the 'to row' value for EACH SENSOR Location plotted.
4.  Click on the 'Rescale when subsetting button'
5.  Click on the 'Subset the data' button.
**********************************************************
**********************************************************
```

Figure 26
["Cookbook Procedure"]

SCAN DATA MENU:
Option 3 <u>Continued</u>

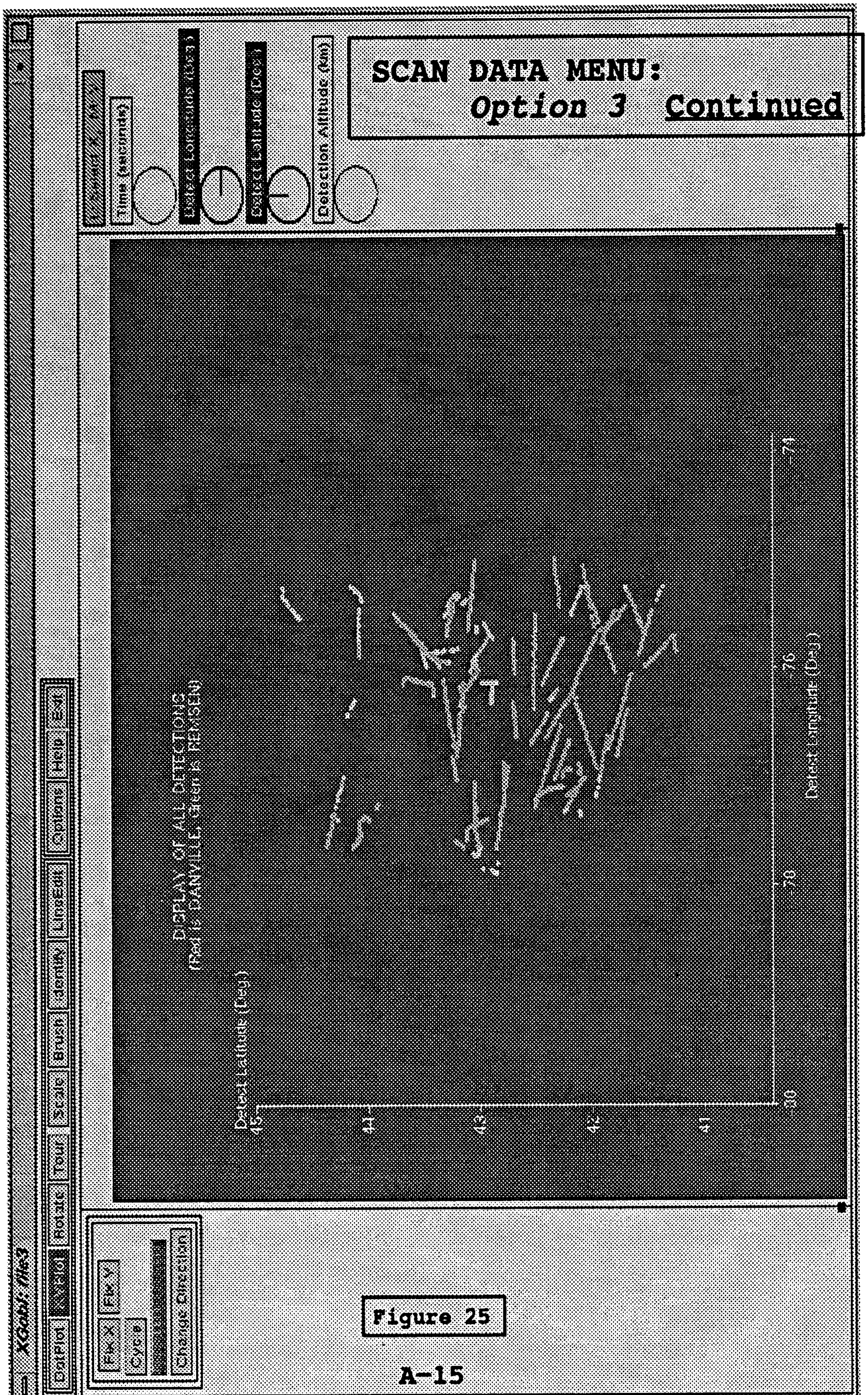


Figure 25

Aspect Ratio REMOVAL - "Cookbook Procedure"

```
**********************************************************
**********************************************************
In order to 'ZOOM IN' on the data (disregard the Aspect Ratio):
1.  Click on the 'Options' button.
2.  When the 'Options' menu appears, click on the 'Subset data' button.
3.  When the 'Subset data' menu appears, click on the 'Consec. block' button
    and subtract 2 from the 'to row' value for the 'Aspect Ratio' points
    and subtract 1 from the 'to row' value for EACH SENSOR Location plotted.
4.  Click on the 'Rescale when subsetting button'.
5.  Click on the 'Subset the data' button.
**********************************************************
**********************************************************
```

Figure 26 (repeated)
["Cookbook Procedure"]

Step 1 yields the display of **Figure 27**.

Step 2 yields the display of **Figure 28**.

Steps 3, 4, and 5 yield the displays of **Figure 29** and the plot of **Figure 31** on page A-18. Contrast this with the original plot of **Figure 30** on page A-17. (Both of these plots were obtained via the **Make postscript plot** button of **Figure 16** on page A-11.)

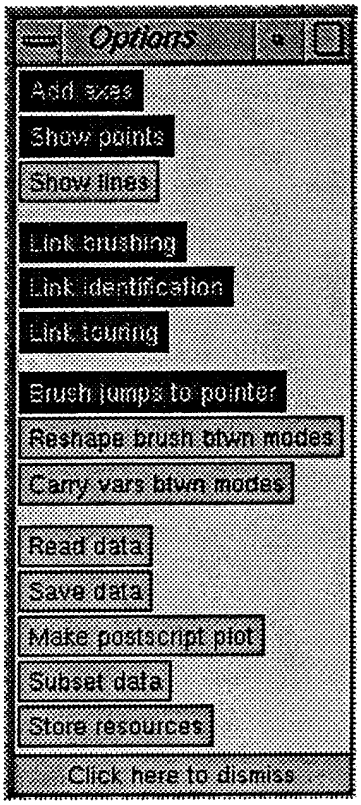


Figure 27

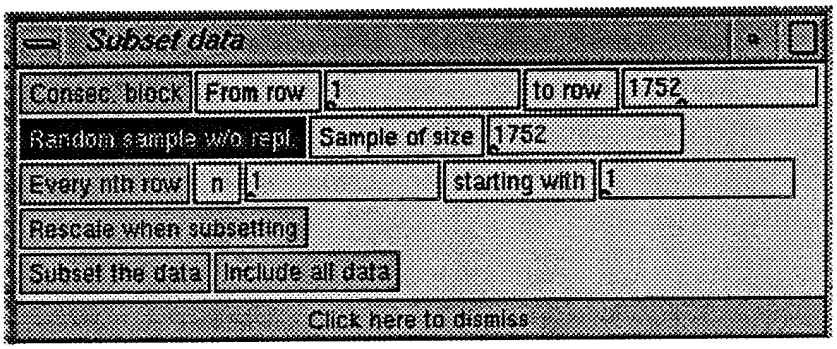


Figure 28

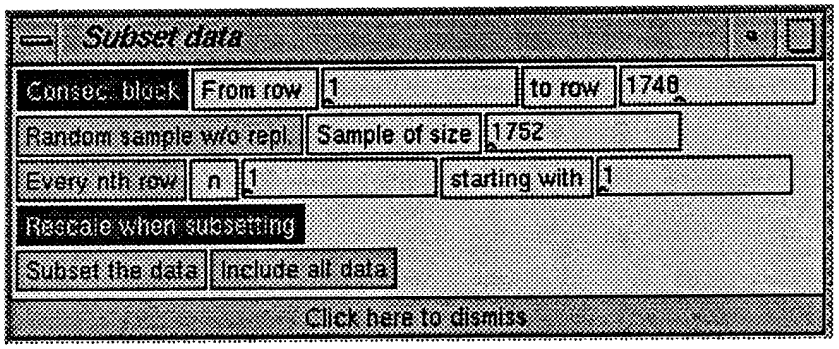


Figure 29

Aspect Ratio REMOVAL "Cookbook Procedure" Continued

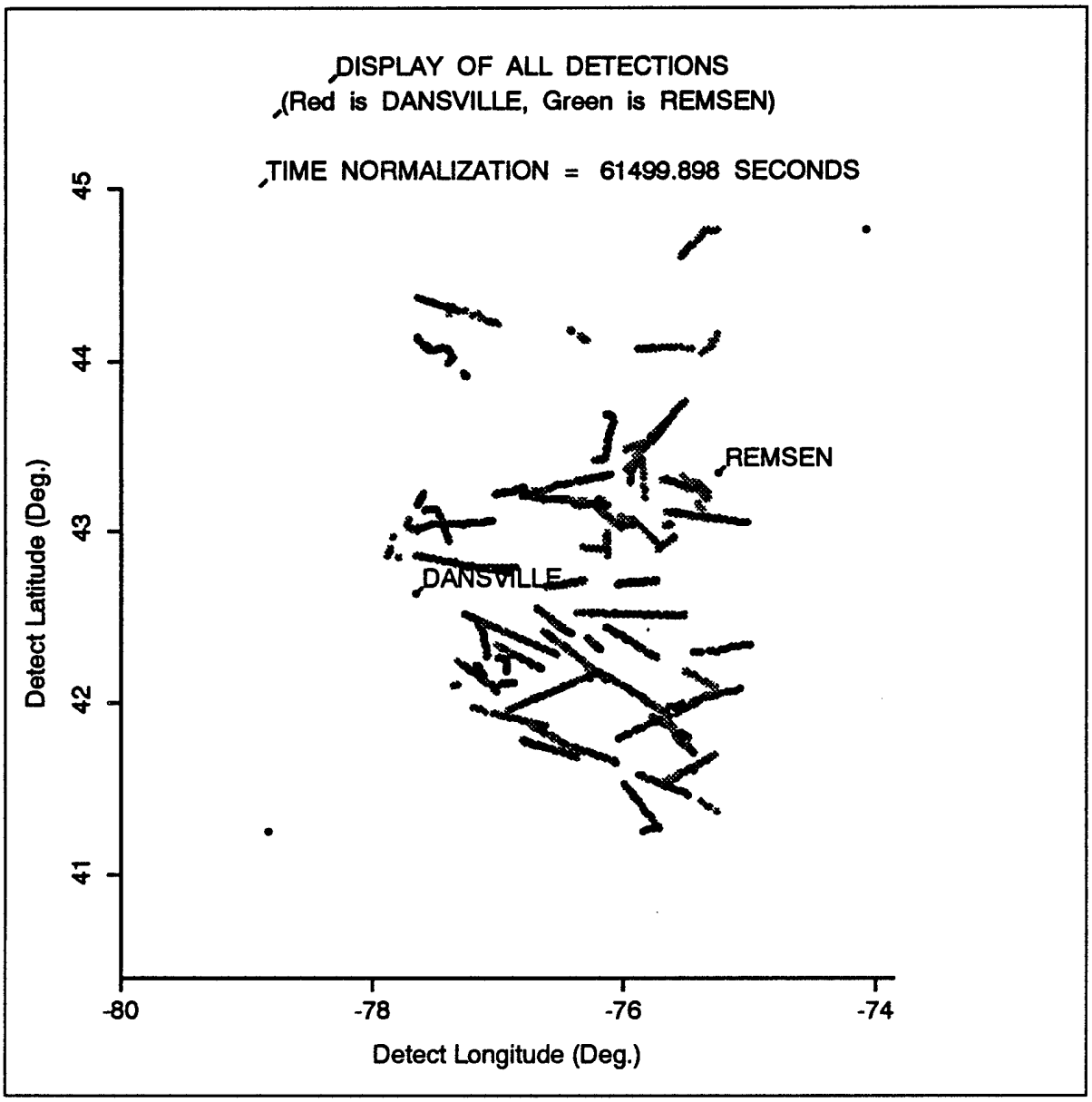


Figure 30

Aspect Ratio REMOVAL "Cookbook Procedure" Continued

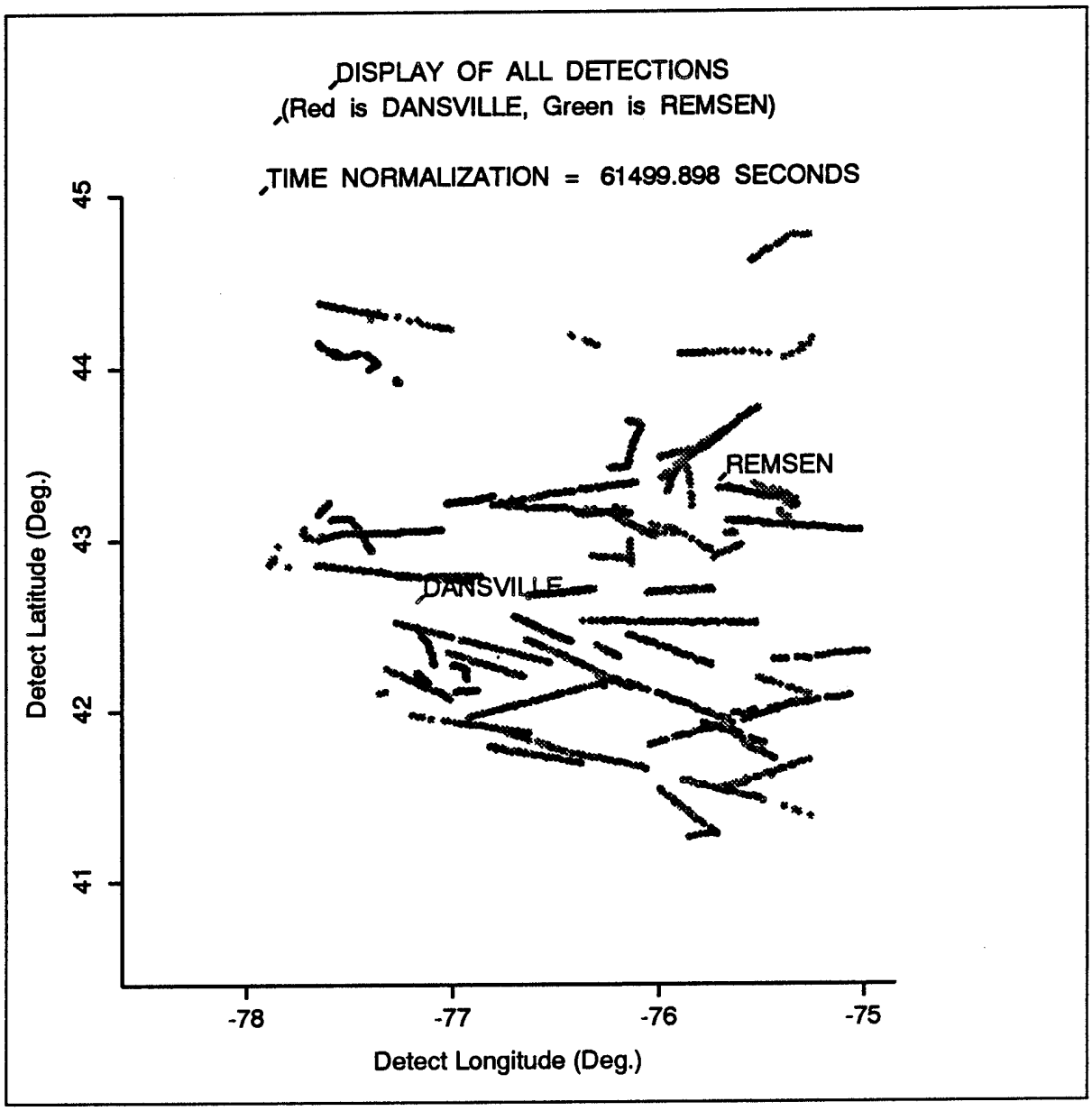


Figure 31

SCAN DATA MENU: *Option 4*

```
SCAN DATA MENU:
  1.  TABULAR Display of Scan Number, Location, # of Detects, Time Interval
  2.  TABULAR Display of Target ID (IFF)  and  Number of Detects per ID
  3.  PLOT ALL SCANS (time, lat, long, alt.)
  4.  SCAN PLOT of (time, lat, long, alt.) data
  5.  TARGET ID PLOT of (time, lat, long, alt.) data
  6.  TRANSFER To Track Data MENU
  7.  QUIT

SCAN DATA plot CHOICE:  3
```

Figure 32

```
SENSOR Display Submenu:
  1.  PLOT Location of Dansville ONLY
  2.  PLOT Location of Remsen ONLY
  3.  PLOT Locations of ALL Sensors
  4.  DO NOT PLOT Location of Any Sensor

SENSOR Display Submenu Choice:  3
```

Figure 24 - Repeated

```
**************************************************
INPUT Scan NUMBER to be Viewed:  1
**************************************************
```

Figure 33

SCAN DATA MENU *Option 4* (**Figure 32**) leads to the INPUTS of **Figures 24 and 33** and then yields the Latitude-Longitude plot of **Figure 34** (default - uses Aspect Ratio) and "blown up" plot of **Figure 35.** [The XGobi **Identify button** (see **Figure 14** on page A-9) has also been clicked on to identify the locations of the two sensors.]

SCAN DATA MENU: *Option 4* Continued

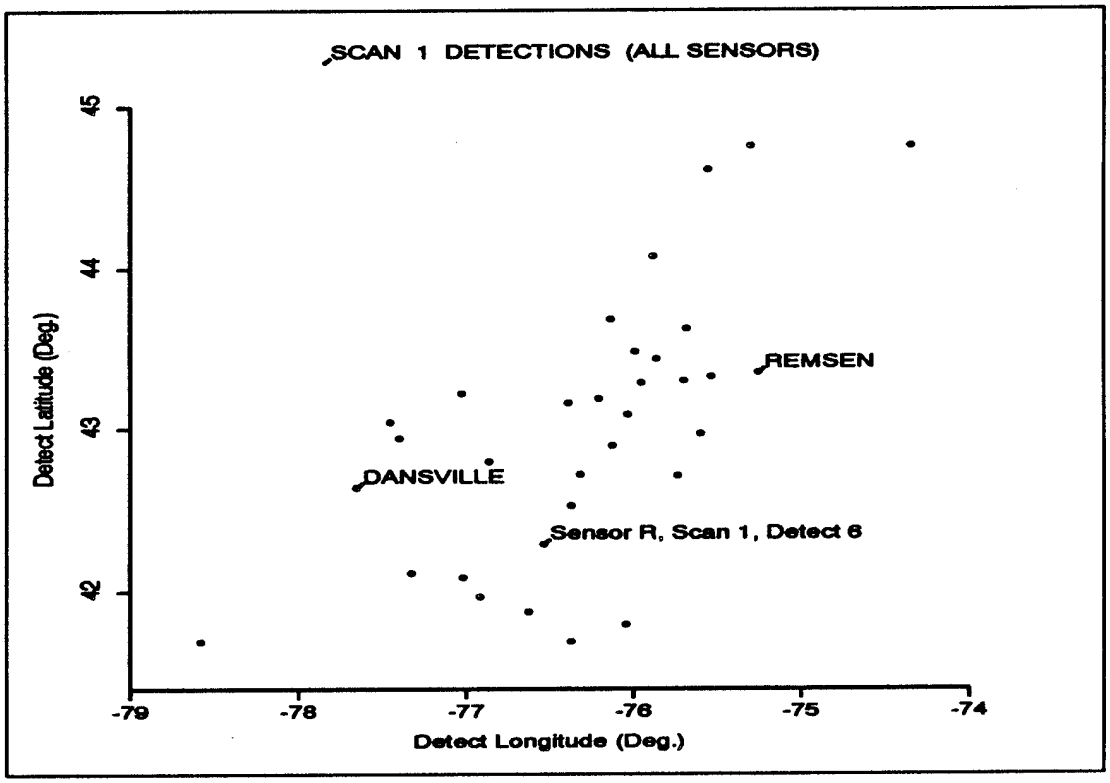


Figure 34

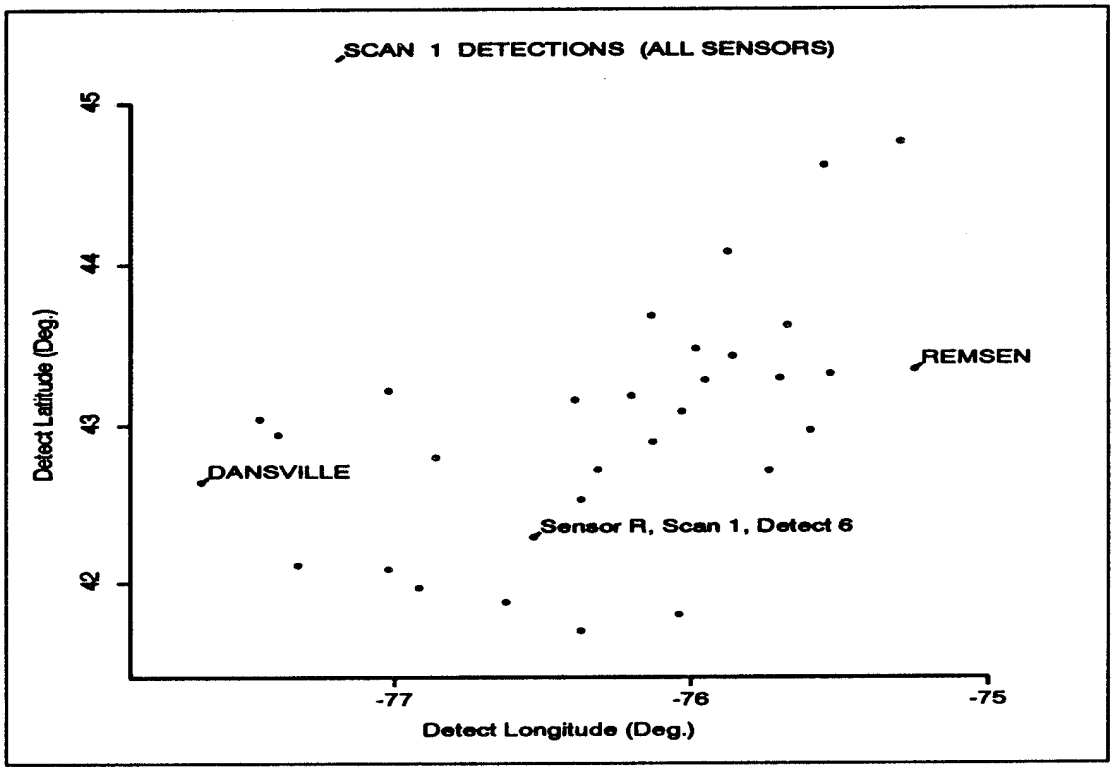


Figure 35

SCAN DATA MENU: *Option 5*

```
SCAN DATA MENU:
  1.  TABULAR Display of Scan Number, Location, # of Detects, Time Interval
  2.  TABULAR Display of Target ID (IFF)  and  Number of Detects per ID
  3.  PLOT ALL SCANS (time, lat, long, alt.)
  4.  SCAN PLOT of (time, lat, long, alt.) data
  5.  TARGET ID PLOT of (time, lat, long, alt.) data
  6.  TRANSFER To Track Data MENU
  7.  QUIT

SCAN DATA plot CHOICE:  5
```

Figure 36

```
SENSOR Display Submenu:
  1.  PLOT Location of Dansville ONLY
  2.  PLOT Location of Remsen ONLY
  3.  PLOT Locations of ALL Sensors
  4.  DO NOT PLOT Location of Any Sensor

SENSOR Display Submenu Choice:  3
```

Figure 24 - Repeated

```
**********************************************************
INPUT Target ID (iff) NUMBER to be Viewed:  1521
**********************************************************
```

Figure 37

SCAN DATA MENU *Option 5* poses the question of **Figures 24 and 37** and then yields the Latitude-Longitude plot of **Figure 38** (default - uses Aspect Ratio) and "blown up" plot of **Figure 39.** **Figure 40** is the plot which results when the response to the Submenu of **Figure 24 - Repeated** is

4. DO NOT PLOT Locations of ALL Sensors

[The XGobi **Identify button** has also been clicked on to identify the locations of the two sensors for **Figures 38 and 39.**]

Finally, *Options 6 and 7* transfer control within the post processor program to <u>either</u> the **Computed Track Data MENU** or to **EXIT.**

SCAN DATA MENU: *Option 5* Continued

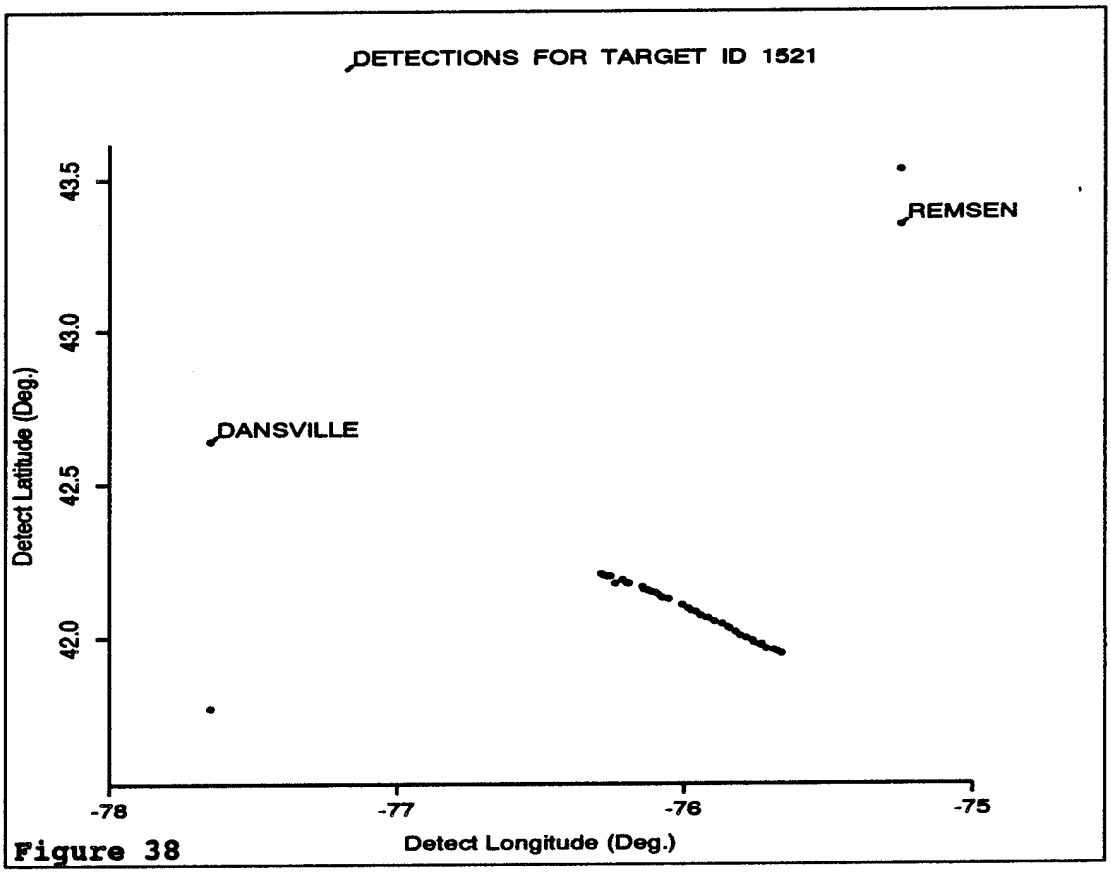


Figure 38

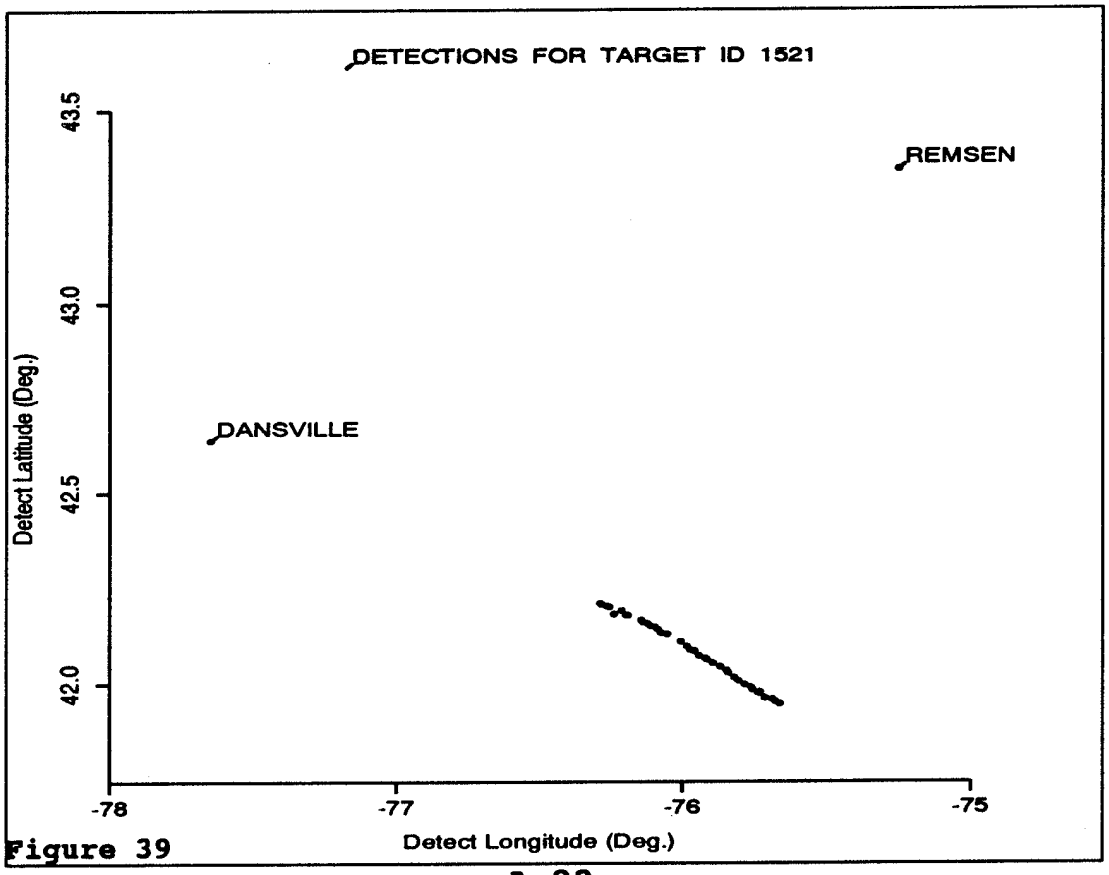


Figure 39

SCAN DATA MENU: *Option 5* Continued

```
SENSOR Display Submenu:
  1.  PLOT Location of Dansville ONLY
  2.  PLOT Location of Remsen ONLY
  3.  PLOT Locations of ALL Sensors
  4.  DO NOT PLOT Location of Any Sensor

SENSOR Display Submenu Choice:  4
```

Figure 24 - Repeated

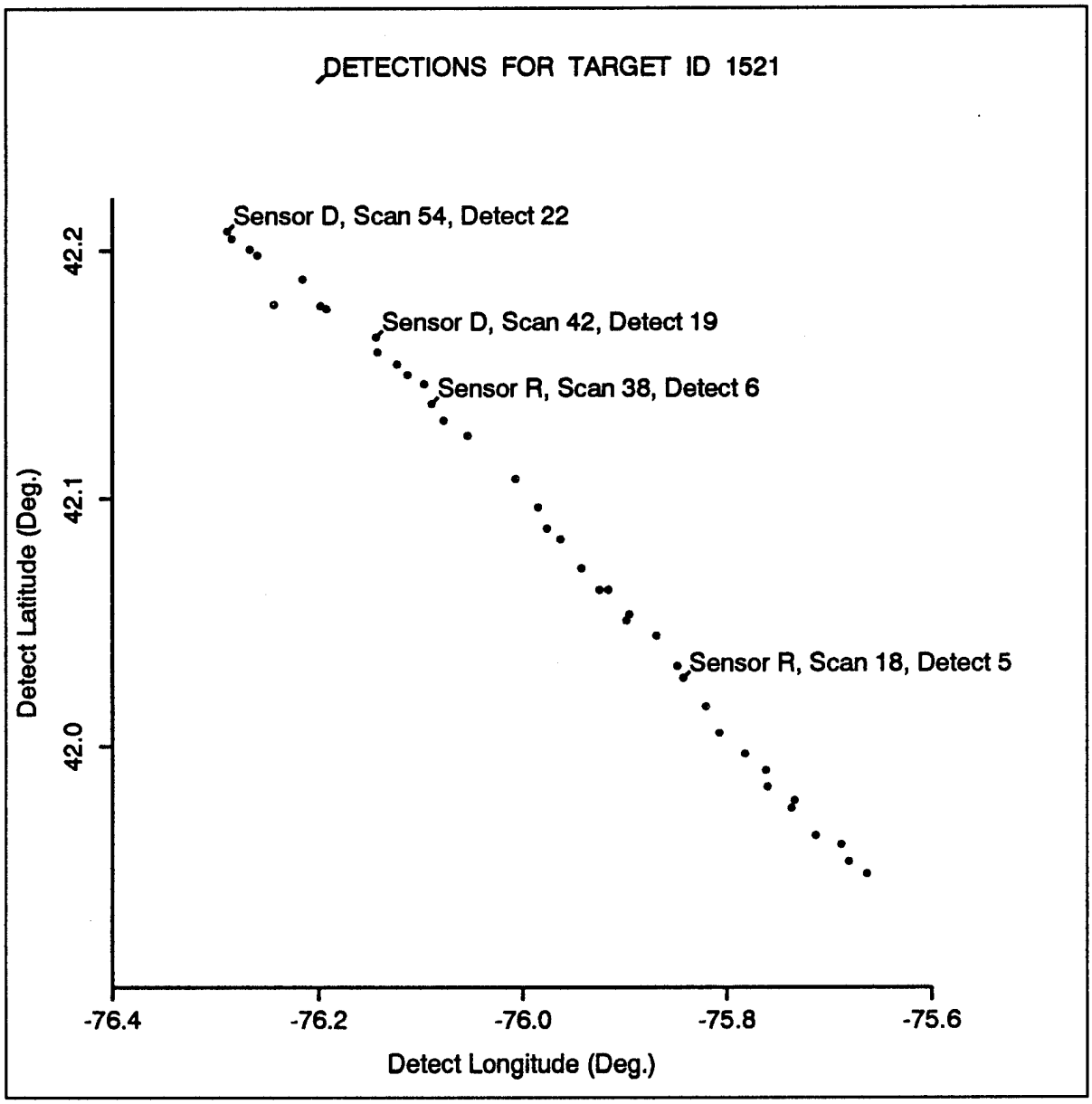


Figure 40

TRACK DISPLAY - COMPUTED DATA DISPLAY

```
Choose the DATA to be Examined:
   1.  SCAN Data
   2.  Track Data
   3.  QUIT

DATA CHOICE:  2
```

Figure 41

```
The COMPUTED Data Set Column HEADINGS ARE:
 0)  Track Time  (seconds)
 1)  Track Number
 2)  Scan Number
 3)  Detect # Within Scan
 4)  LatestAssoc.Detect Long.
 5)  LatestAssoc.Detect Lat.
 6)  LatestAssoc.Detect Alt.
 7)  TRACK Longitude (Deg.)
 8)  TRACK Latitude (Deg.)
 9)  TRACK Altitude (km)
10)  Vel. Due North (km/s)
11)  Vel. Due East (km/s)
12)  Vertical Vel. Up (km/s)
13)  Velocity Magnitude
14)  Cost
15)  Target ID
16)  TRACK Cov. dueNorth (km)
17)  TRACK Cov. due East (km)
18)  TRACK Cov. Up (km)
19)  TRACK Cov. NE (km)
20)  TRACK Cov. N UP (km)
21)  TRACK Cov. E UP (km)

    The variable(s) to be identified:  Detection # Within Scan


              [There should be 1 integer inputs.]

[Choose the column number from the above list which corresponds to the above named variable(s).]
       [INPUT a -1 if there is no data which corresponds to this variable(s).]
3
```

Figure 42

```
The COMPUTED Data Set Column HEADINGS ARE:
  0)  Track Time  (seconds)
  1)  Track Number
  2)  Scan Number
  3)  Detect # Within Scan
  4)  LatestAssoc.Detect Long.
  5)  LatestAssoc.Detect Lat.
  6)  LatestAssoc.Detect Alt.
  7)  TRACK Longitude (Deg.)
  8)  TRACK Latitude (Deg.)
  9)  TRACK Altitude (km)
 10)  Vel. Due North (km/s)
 11)  Vel. Due East (km/s)
 12)  Vertical Vel. Up (km/s)
 13)  Velocity Magnitude
 14)  Cost
 15)  Target ID
 16)  TRACK Cov. dueNorth (km)
 17)  TRACK Cov. due East (km)
 18)  TRACK Cov. Up (km)
 19)  TRACK Cov. NE (km)
 20)  TRACK Cov. N UP (km)
 21)  TRACK Cov. E UP (km)

     The variable(s) to be identified:  Velocity ID (North, East, Up, Magnitude)


                  [There should be 4 integer inputs.]

[Choose the column number from the above list which corresponds to the above named variable(s).]
        [INPUT a -1 if there is no data which corresponds to this variable(s).]
10
11
12
13
```

Figure 43
A-25

TRACK DATA MENU: *Option 0*

The largest part of the post-processing code is to display data which has been generated by the Algorithm in question. To reach these Options, invoke the program and choose **2. Track Data** from the menu of **Figure 41** (page A-24).

What appears next is a list of variables which have been saved by the running of the Algorithm and a request of the User to identify a particular variable needed for the various statistical computations and plots (Examples - **Figure 42** on page A-24 and **Figure 43** on page A-25). The variable(s) to be identified is(are) described and the User is told how many inputs are needed. As with the SCAN data, if a requested variable is **not available**, a **-1** should be input. [Later on when the User tries to exercise a particular *Option*, there exists the logic to test whether or not data is available for that particular *Option* and to print out an error message if the User chooses an *Option* for which data is unavailable.]

Figure 44 below, the **Track Data Menu**, then offers the User a choice of *Options*.

Option **0. PLOT Tracks** is chosen and the "Submenu" is displayed. **Figure 45** on the next page illustrates this Submenu and the error message which occurs if the User responds incorrectly.

The User is then asked whether or not the Sensor locations should be plotted (**Figure 24 - Repeated** on page A-27).

1. Plot ALL Tracks is chosen. This will result initially in a plot of Longitude vs. Track Time (**Figure 46** on page A-28 and **Figure 46(normalized)** on page A-29). [The **Identify** button has been clicked on to label Sensor locations.]

Figure 47 on page A-28 and **Figure 47(normalized)** are plots of Latitude vs. Longitude with the Aspect Ratio points removed from the plotting data set (see pages A-14 to A-18).

```
Track Data MENU 2:
 0. PLOT Tracks
 1. Output Tables by Track Numbers containing Number of Associated Detections and:
    a. Minimum time and Maximum time
    b. Range of Track Coordinates
 2. PLOT One Track
 3. PLOT One Track and Associated Detections
 4. PLOT Association Cost
 5. COMPUTE TABULAR Summary of Innovation (Detections - Track) along with corresponding plot.
 6. OUTPUT a Table of Target ID vs. Associated Tracks
 7. PLOT Track Covariances vs. Time
 8. PLOT Covariance Ellipses for Detections vs. Tracks
 9. PRINT OUT (by time tick) Selected Data Corresponding to a Particular Track
10. PLOT ALL Track Points Corresponding to a Particular Target ID
11. PLOT Velocity by Track
12. TRANSFER to Scan Data Menu
13. QUIT
MENU Choice:  0
```

Figure 44

TRACK DATA MENU: *Option 0* Continued

PLOT Tracks Submenu: *Option 1*

```
**********************************************************
PLOT Tracks Submenu:
  1.  Plot ALL Tracks
  2.  Plot all tracks within a specified (Long., Lat., Alt.) Window
  3.  Plot all tracks within a specified TIME Window
  4.  Plot SPECIFIC Tracks
PLOT Tracks Submenu Choice:  0
**********************************************************
**********************************************************
ERROR in Data INPUT:
    INPUTTED Value:  0
[1 or 2 or 3 or 4 are the only acceptable values.]
     Please Try AGAIN.
**********************************************************

**********************************************************
PLOT Tracks Submenu:
  1.  Plot ALL Tracks
  2.  Plot all tracks within a specified (Long., Lat., Alt.) Window
  3.  Plot all tracks within a specified TIME Window
  4.  Plot SPECIFIC Tracks
PLOT Tracks Submenu Choice:  1
**********************************************************
```

Figure 45

```
SENSOR Display Submenu:
  1.  PLOT Location of Dansville ONLY
  2.  PLOT Location of Remsen ONLY
  3.  PLOT Locations of ALL Sensors
  4.  DO NOT PLOT Location of Any Sensor

SENSOR Display Submenu Choice:  3
```

Figure 24 – Repeated

TRACK DATA MENU: *Option 0* Continued

PLOT Tracks Submenu: *Option 1* - Continued

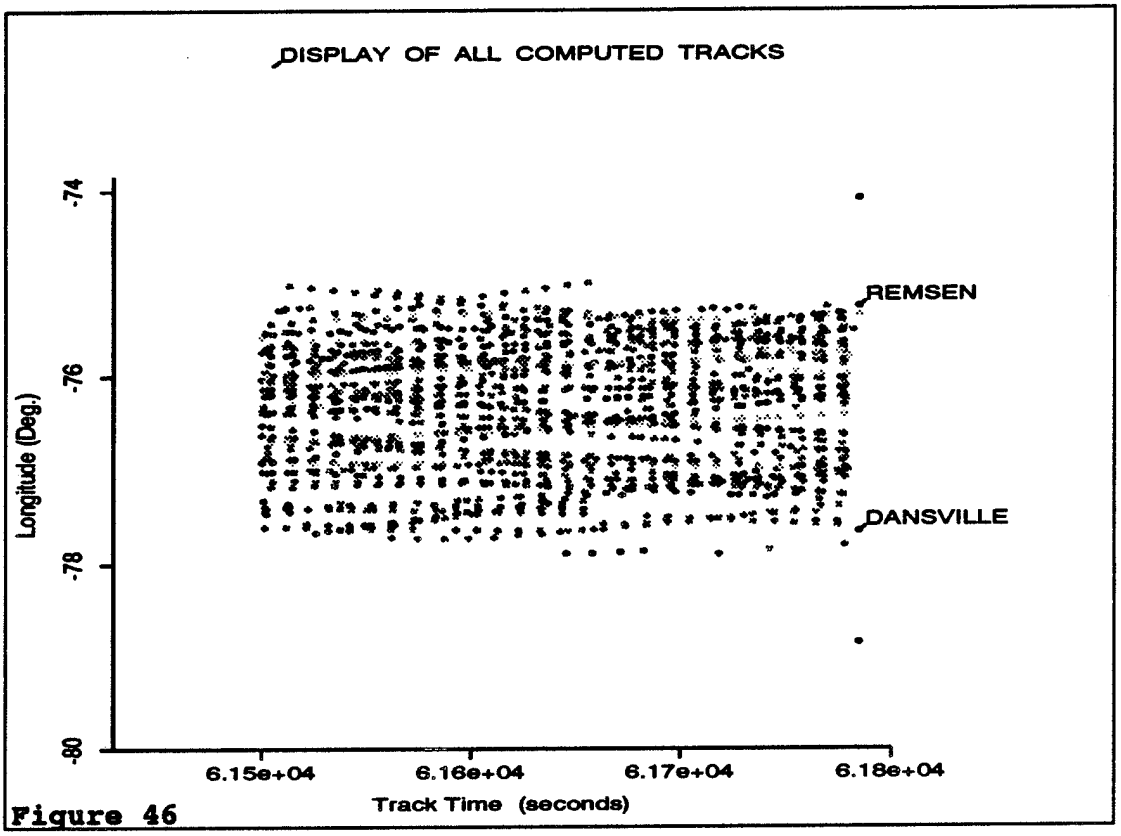


Figure 46

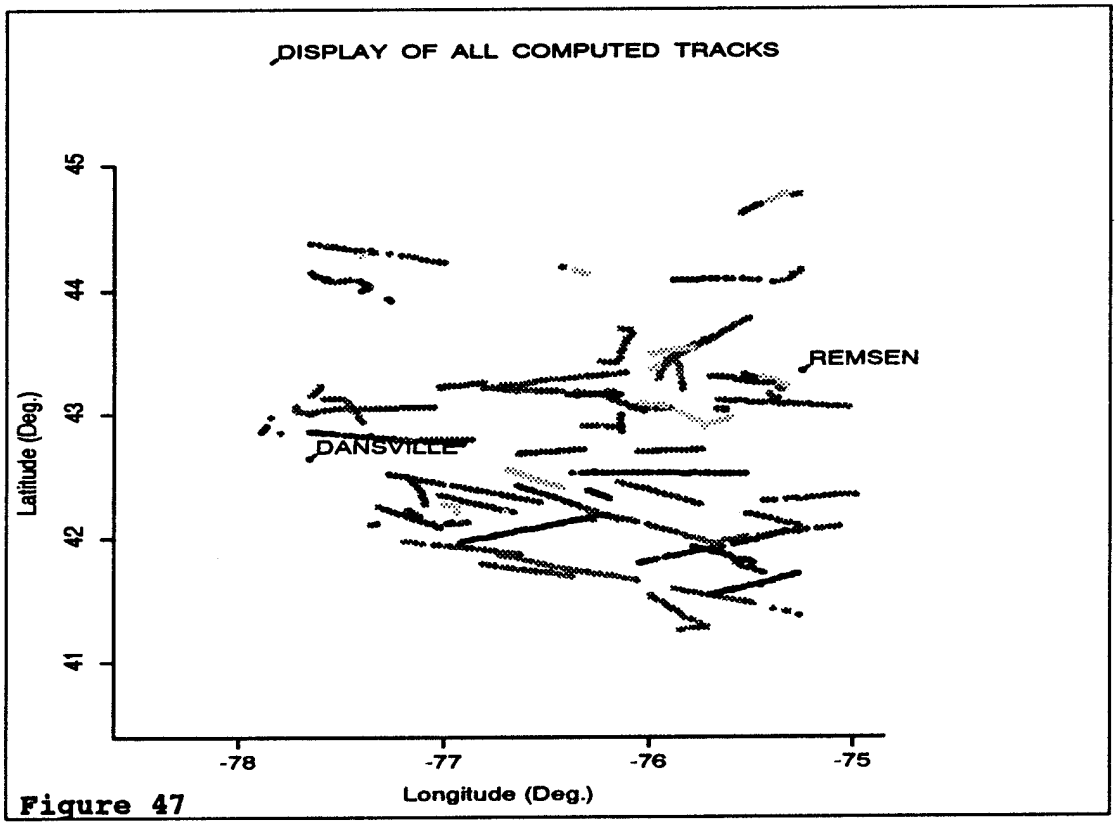


Figure 47

TRACK DATA MENU: *Option 0* Continued

PLOT Tracks Submenu: *Option 1* - Continued

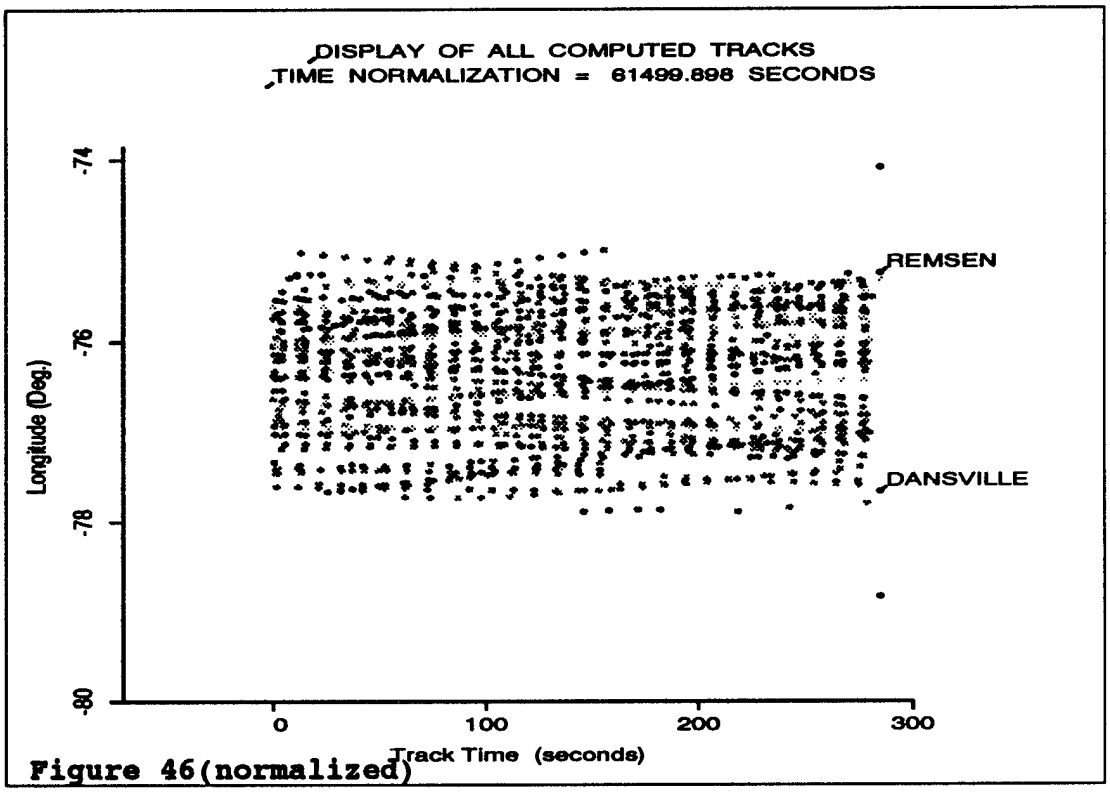


Figure 46(normalized)

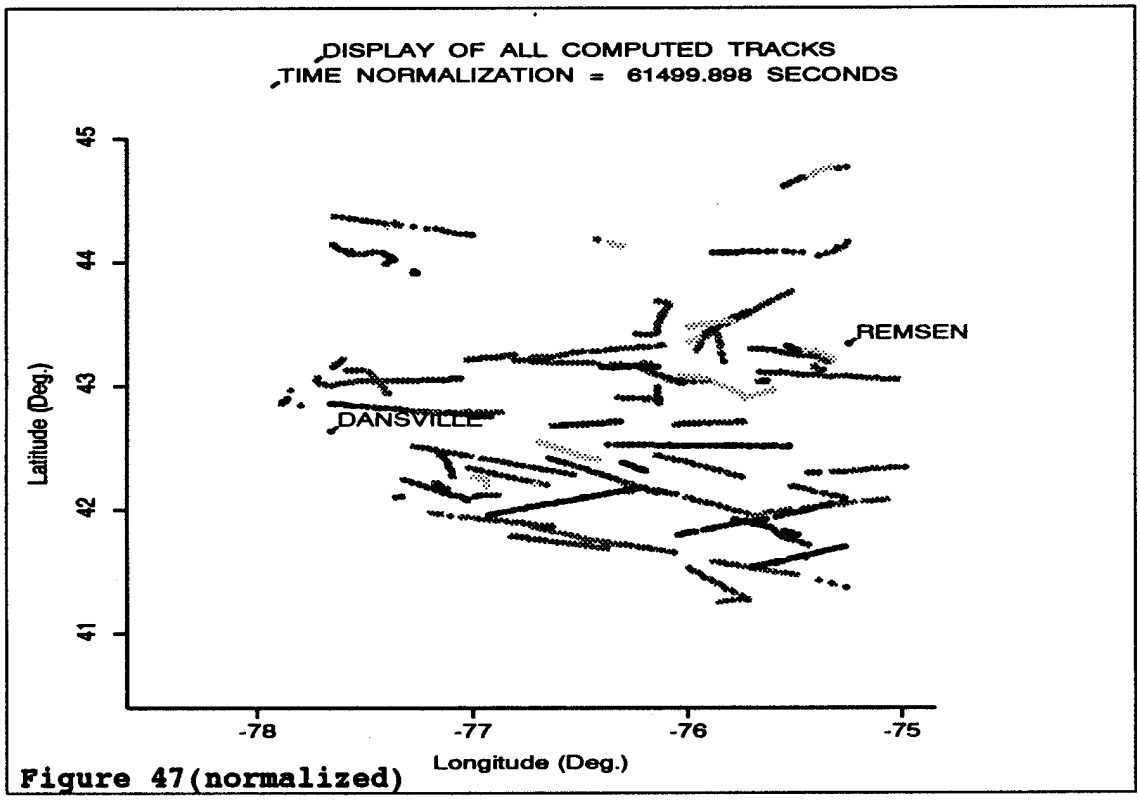


Figure 47(normalized)

TRACK DATA MENU: *Option 0* Continued

PLOT Tracks Submenu: *Option 2*

```
Track Data MENU 2:
 0.  PLOT Tracks
  1.  Output Tables by Track Numbers containing Number of Associated Detections and:
      a.  Minimum time and Maximum time
      b.  Range of Track Coordinates
  2.  PLOT One Track
  3.  PLOT One Track and Associated Detections
  4.  PLOT Association Cost
  5.  COMPUTE TABULAR Summary of Innovation (Detections - Track) along with corresponding plot.
  6.  OUTPUT a Table of Target ID vs. Associated Tracks
  7.  PLOT Track Covariances vs. Time
  8.  PLOT Covariance Ellipses for Detections vs. Tracks
  9.  PRINT OUT (by time tick) Selected Data Corresponding to a Particular Track
 10.  PLOT ALL Track Points Corresponding to a Particular Target ID
 11.  PLOT Velocity by Track
 12.  TRANSFER to Scan Data Menu
 13.  QUIT
MENU Choice:  0
```

Figure 48

```
SENSOR Display Submenu:
  1.  PLOT Location of Dansville ONLY
  2.  PLOT Location of Remsen ONLY
  3.  PLOT Locations of ALL Sensors
  4.  DO NOT PLOT Location of Any Sensor

SENSOR Display Submenu Choice:  3
```

Figure 24 - Repeated

```
PLOT Tracks Submenu:
  1.  Plot ALL Tracks
  2.  Plot all tracks within a specified (Long., Lat., Alt.) Window
  3.  Plot all tracks within a specified TIME Window
  4.  Plot SPECIFIC Tracks
PLOT Tracks Submenu Choice:  2
```

Figure 49

Option 2 of the **PLOT Tracks Submenu** allows the User to specify a range of Longitude, Latitude, and Altitude in which he/she would like to see a display of all calculated Tracks (**Figure 50** on page A-31).

The initial plot which results from these inputs is a plot of Longitude vs. Track Time (**Figure 51** on page A-31 or **Figure 51(normalized)** on page A-32).

The Latitude vs. Longitude plots for this case are **Figure 52** on page A-33 and **Figure 53** (with Aspect Ratio points removed from the plotting) on page A-33.

TRACK DATA MENU: *Option 0* Continued

PLOT Tracks Submenu: *Option 2* - Continued

```
**********************************************************
**********************************************************
ALL Tracks within a certain geometric Window are to be plotted.

     INPUT MINIMUM and MAXIMUM values for Longitude (Deg.):
-77 -76
**********************************************************
**********************************************************
ALL Tracks within a certain geometric Window are to be plotted.

     INPUT MINIMUM and MAXIMUM values for Latitude (Deg.):
43 44
**********************************************************
**********************************************************
ALL Tracks within a certain geometric Window are to be plotted.

     INPUT MINIMUM and MAXIMUM values for Altitude (km)  :
0 400
**********************************************************
**********************************************************
```

Figure 50

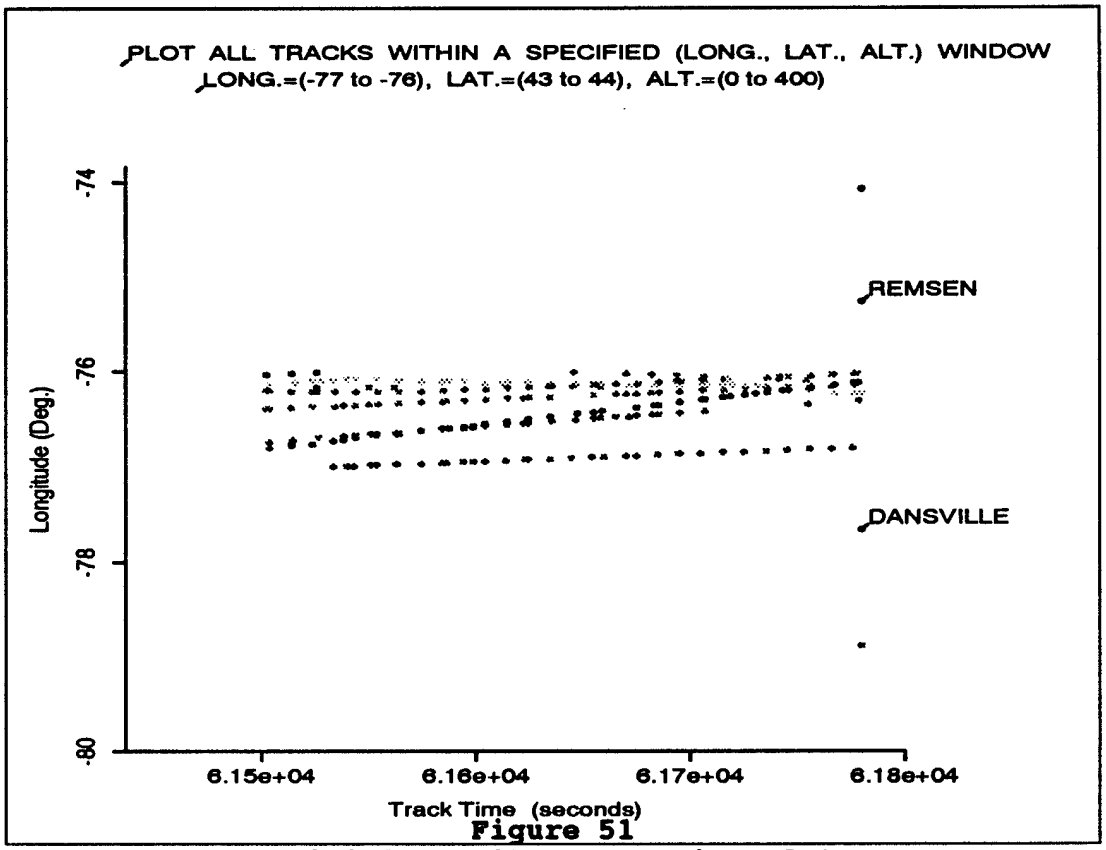


Figure 51

[Initial Longitude vs. Time Plot]

TRACK DATA MENU: *Option 0* Continued

PLOT Tracks Submenu: *Option 2* - Continued

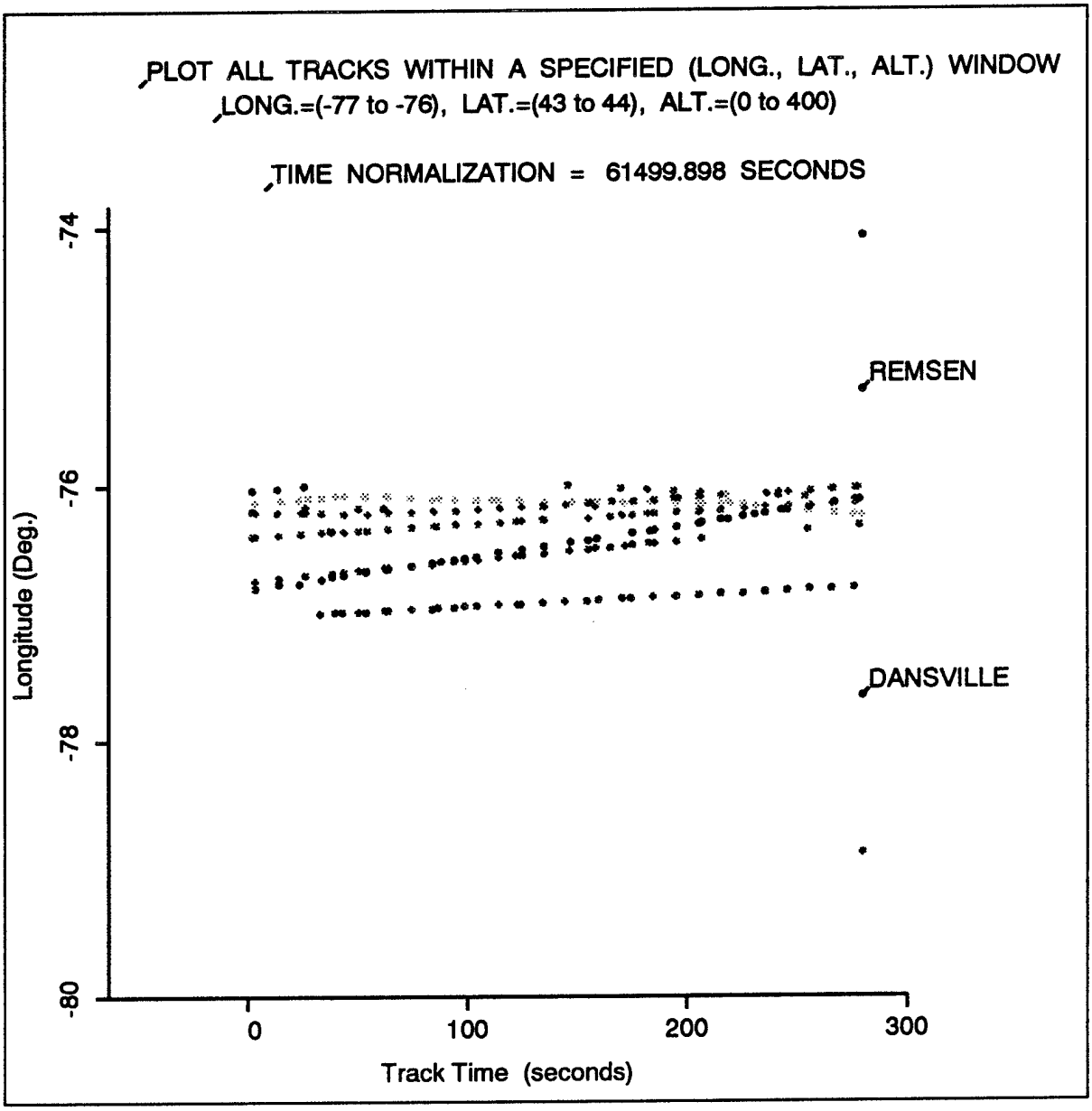


Figure 51(normalized)
[Initial Longitude vs. Time Plot]

TRACK DATA MENU: *Option 0* Continued

PLOT Tracks Submenu: *Option 2* - Continued

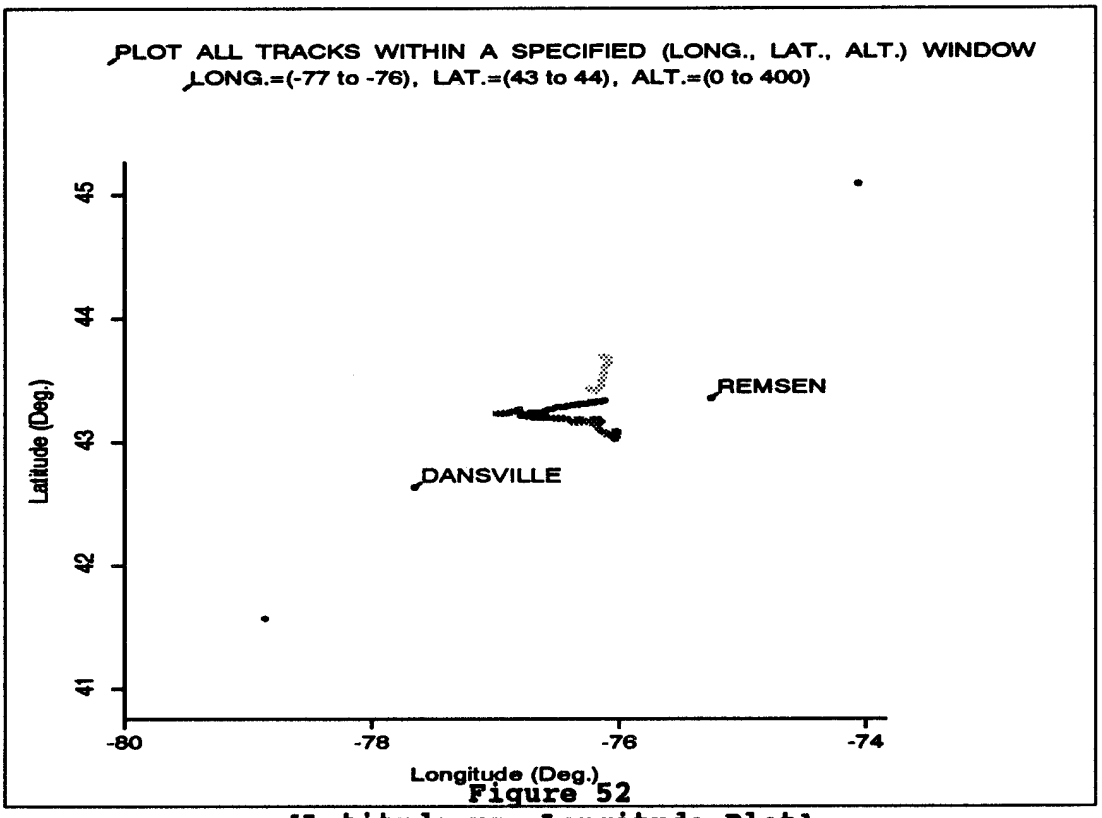


Figure 52

[Latitude vs. Longitude Plot]

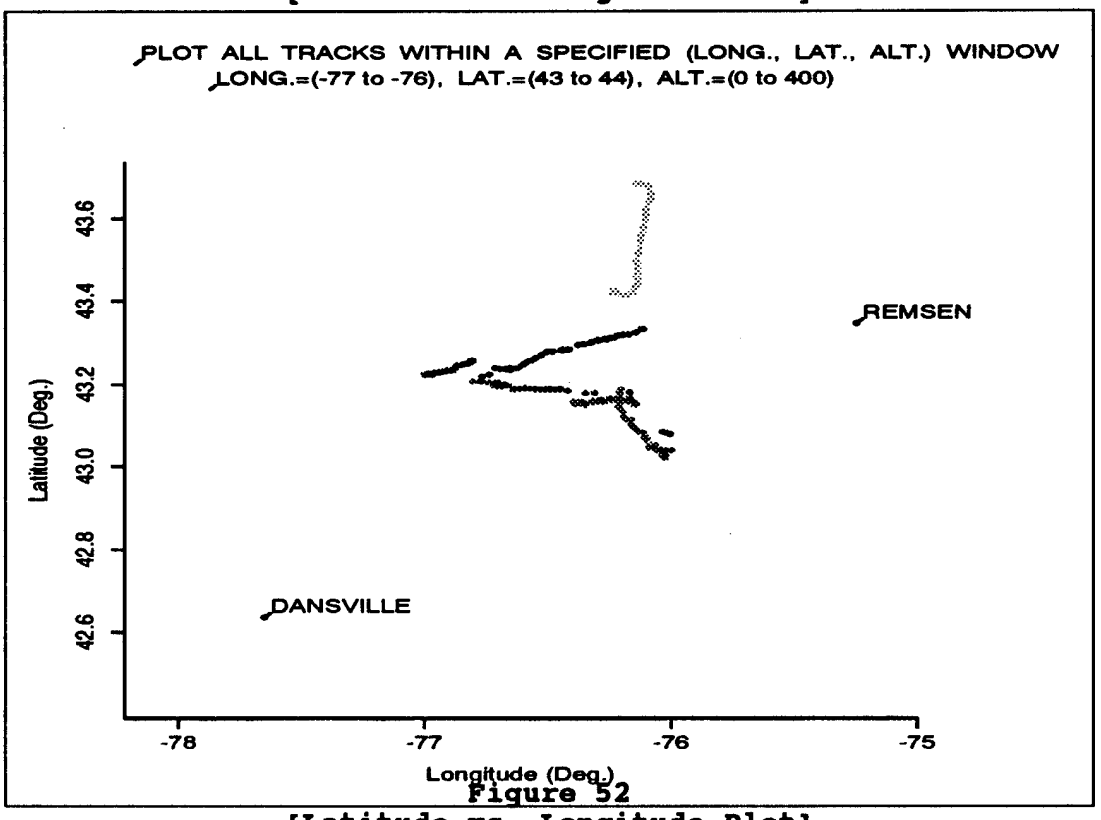


Figure 52

[Latitude vs. Longitude Plot]

TRACK DATA MENU: *Option 0* Continued

PLOT Tracks Submenu: *Option 3*

```
Track Data MENU 2:
 0.  PLOT Tracks
 1.  Output Tables by Track Numbers containing Number of Associated Detections and:
     a.  Minimum time and Maximum time
     b.  Range of Track Coordinates
 2.  PLOT One Track
 3.  PLOT One Track and Associated Detections
 4.  PLOT Association Cost
 5.  COMPUTE TABULAR Summary of Innovation (Detections - Track) along with corresponding plot.
 6.  OUTPUT a Table of Target ID vs. Associated Tracks
 7.  PLOT Track Covariances vs. Time
 8.  PLOT Covariance Ellipses for Detections vs. Tracks
 9.  PRINT OUT (by time tick) Selected Data Corresponding to a Particular Track
10.  PLOT ALL Track Points Corresponding to a Particular Target ID
11.  PLOT Velocity by Track
12.  TRANSFER to Scan Data Menu
13.  QUIT
MENU Choice:  0
```

Figure 54

```
PLOT Tracks Submenu:
  1.  Plot ALL Tracks
  2.  Plot all tracks within a specified (Long., Lat., Alt.) Window
  3.  Plot all tracks within a specified TIME Window
  4.  Plot SPECIFIC Tracks
PLOT Tracks Submenu Choice:  3
```

Figure 55

```
**********************************************************
**********************************************************
ALL Tracks within a certain TIME Window are to be plotted.

     INPUT MINIMUM and MAXIMUM values for this TIME WINDOW:
61500 61600
**********************************************************
**********************************************************
```

Figure 56

Option 3 of the **PLOT Tracks Submenu** (**Figure 55**) allows the User to specify a range of Time in which he/she would like to see a display of all calculated Tracks which were active during that range of time(**Figure 56**).

The initial plot which results from these inputs is a plot of Longitude vs. Track Time, **Figure 57** on page A-31 or **Figure 57(normalized)** on page A-32. This latter plot has Track points connected and **Figure 59** on page A-31 illustrates the times which were input by the User to generate this plot.

A Latitude vs. Longitude plot for this case, with Aspect Ratio points removed from the plotting, is **Figure 58** on page A-31.

TRACK DATA MENU: *Option 0* Continued

PLOT Tracks Submenu: *Option 3* - Continued

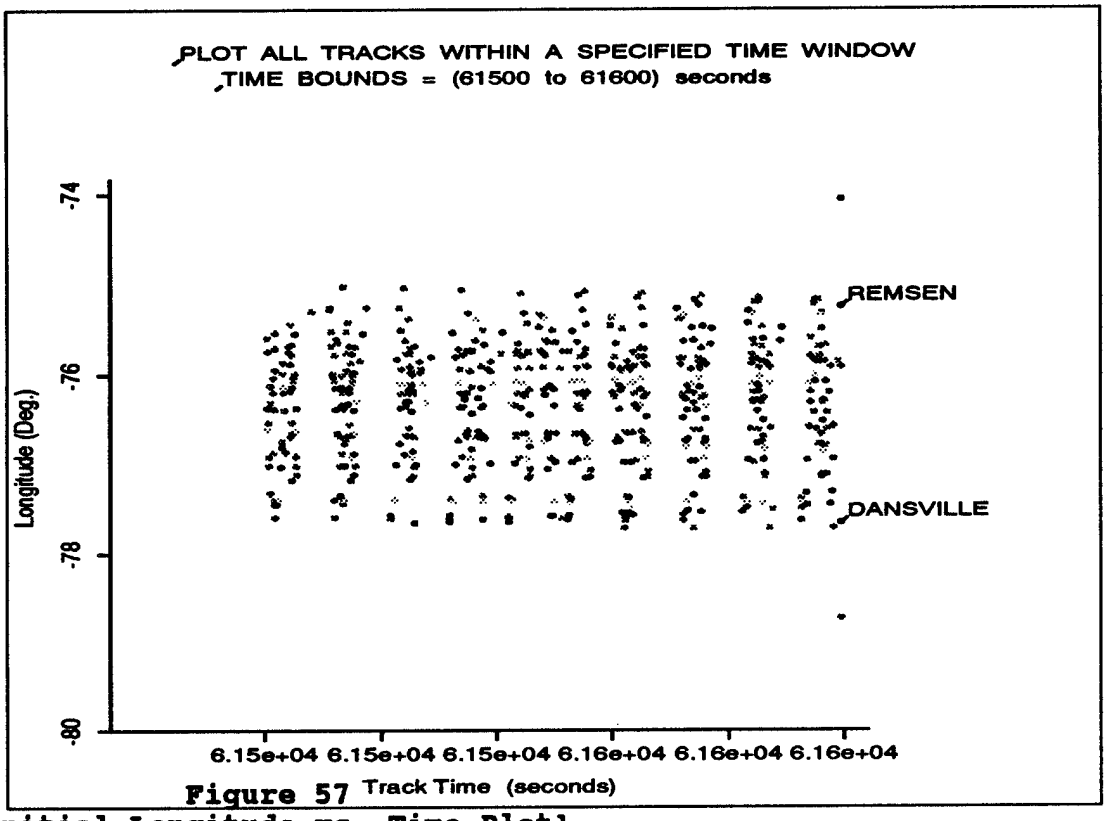


Figure 57 [Initial Longitude vs. Time Plot]

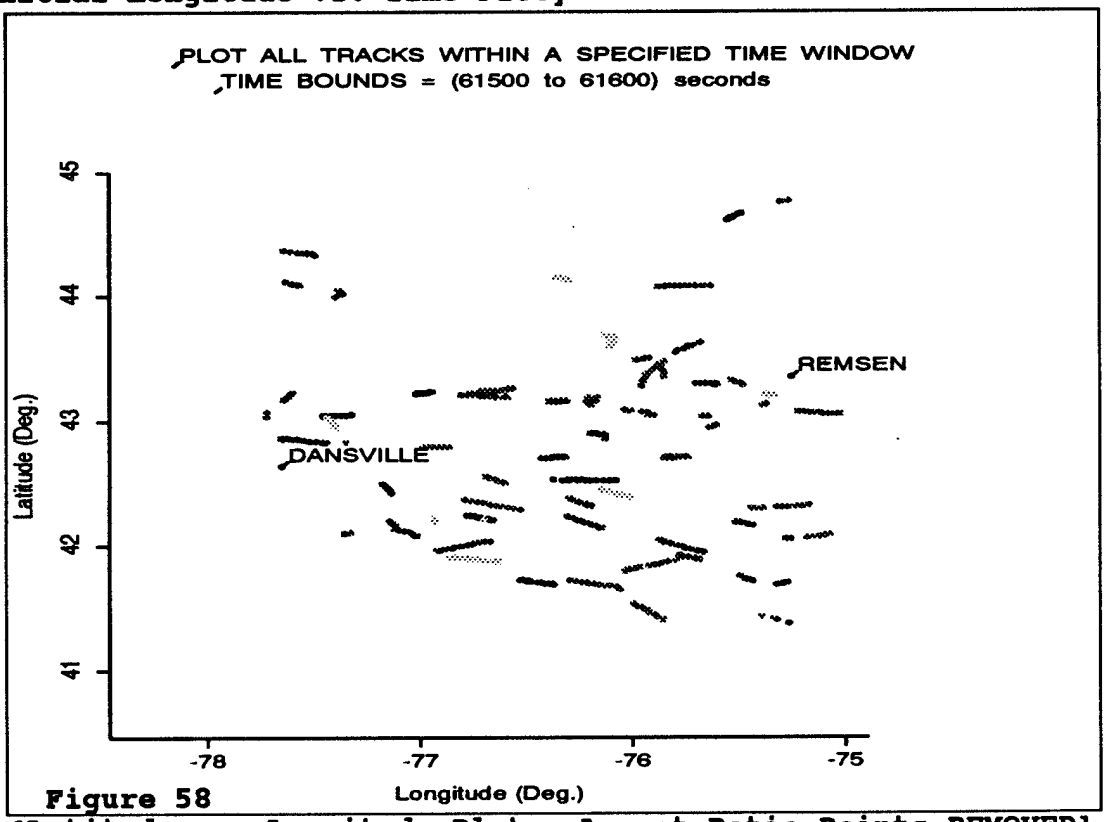


Figure 58 [Latitude vs. Longitude Plot - Aspect Ratio Points REMOVED]

TRACK DATA MENU: *Option 0* Continued

PLOT Tracks Submenu: *Option 3* - Continued

```
**************************************************
**************************************************
ALL Tracks within a certain TIME Window are to be plotted.

     INPUT MINIMUM and MAXIMUM values for this TIME WINDOW:
0 100
**************************************************
**************************************************
```

Figure 59

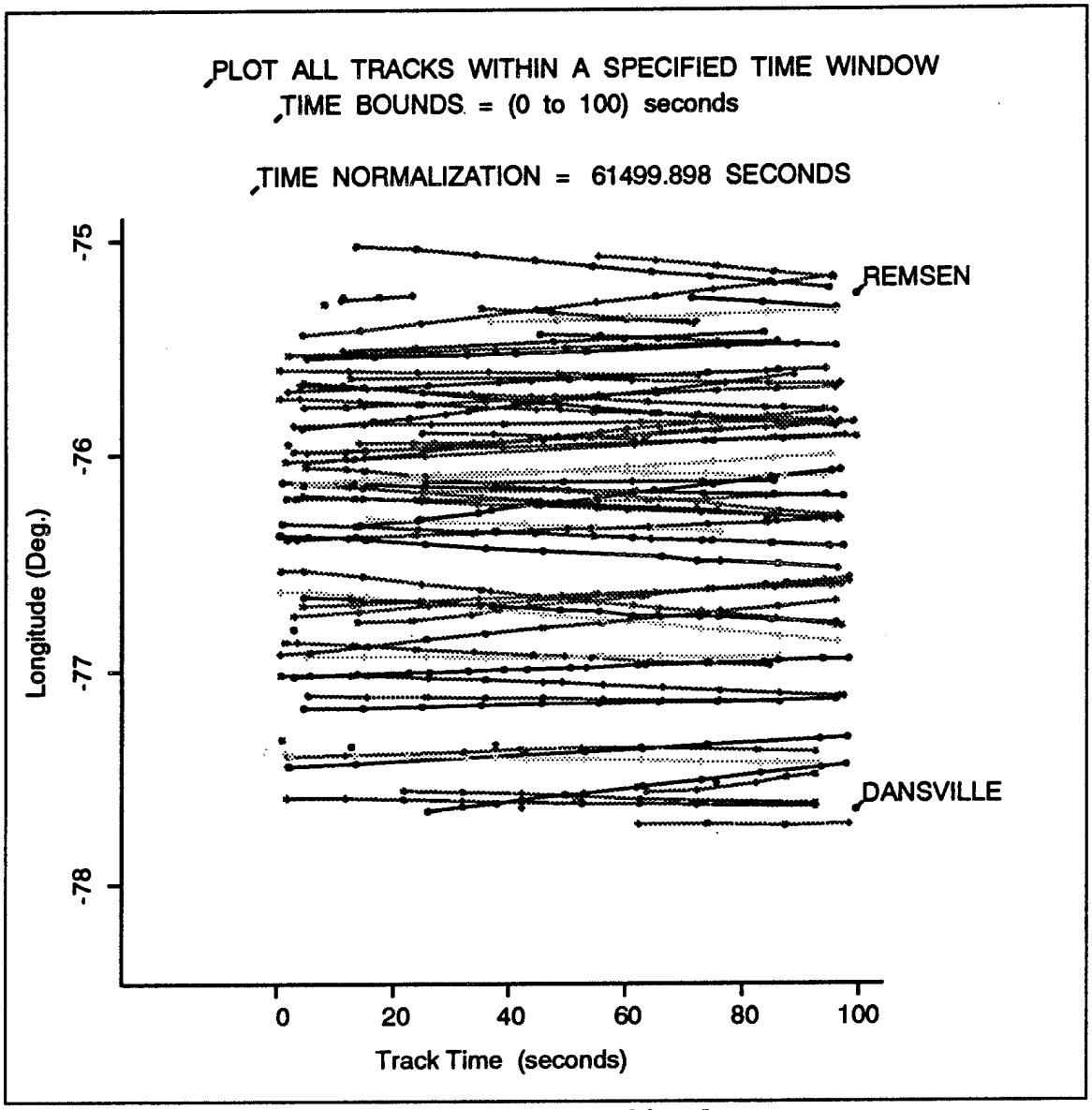


Figure 57(normalized)
[Initial Longitude vs. Time Plot]
{Individual Track Points are Connected}

TRACK DATA MENU: *Option 0* Continued

PLOT Tracks Submenu: *Option 4*

```
Track Data MENU 2:
 0.  PLOT Tracks
  1.  Output Tables by Track Numbers containing Number of Associated Detections and:
      a.  Minimum time and Maximum time
      b.  Range of Track Coordinates
  2.  PLOT One Track
  3.  PLOT One Track and Associated Detections
  4.  PLOT Association Cost
  5.  COMPUTE TABULAR Summary of Innovation (Detections - Track) along with corresponding plot.
  6.  OUTPUT a Table of Target ID vs. Associated Tracks
  7.  PLOT Track Covariances vs. Time
  8.  PLOT Covariance Ellipses for Detections vs. Tracks
  9.  PRINT OUT (by time tick) Selected Data Corresponding to a Particular Track
 10.  PLOT ALL Track Points Corresponding to a Particular Target ID
 11.  PLOT Velocity by Track
 12.  TRANSFER to Scan Data Menu
 13.  QUIT
MENU Choice:  0
```

Figure 60

```
PLOT Tracks Submenu:
  1.  Plot ALL Tracks
  2.  Plot all tracks within a specified (Long., Lat., Alt.) Window
  3.  Plot all tracks within a specified TIME Window
  4.  Plot SPECIFIC Tracks
PLOT Tracks Submenu Choice:  4
```

Figure 61

```
SENSOR Display Submenu:
  1.  PLOT Location of Dansville ONLY
  2.  PLOT Location of Remsen ONLY
  3.  PLOT Locations of ALL Sensors
  4.  DO NOT PLOT Location of Any Sensor

SENSOR Display Submenu Choice:  3
```

Figure 24 - Repeated

```
**********************************************************
**********************************************************
INPUT the Track Numbers to be displayed (one number per line):
        [TERMINATE Data Entry with a zero]
21
70
105
0
```

Figure 62

Again, the first plot which occurs as a result of these INPUTS is that of **Figure 63** on the next page (or **Figure 63(normalized)** on page A-39). The ASPECT RATIO scaling points are removed and the axes are changed to "Longitude" and "Latitude" in order to obtain the plot of **Figure 64.**

TRACK DATA MENU: *Option 0* Continued

PLOT Tracks Submenu: *Option 4* - Continued

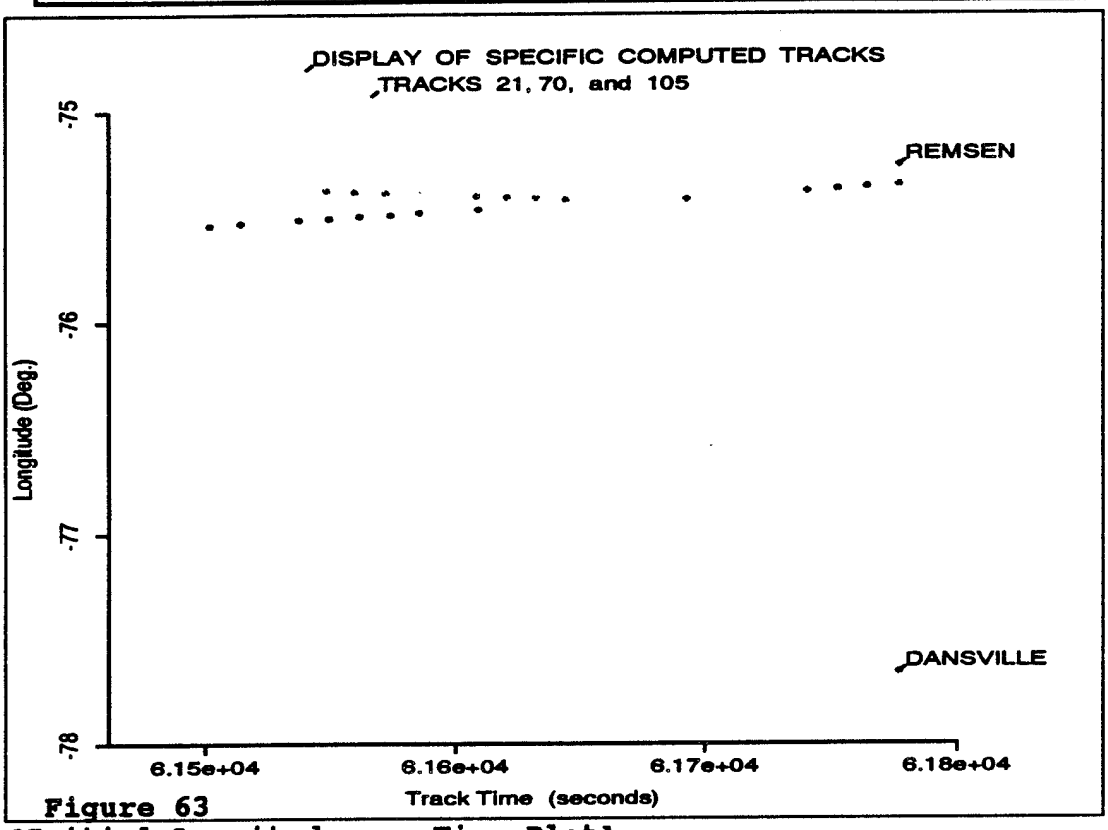


Figure 63

[Initial Longitude vs. Time Plot]

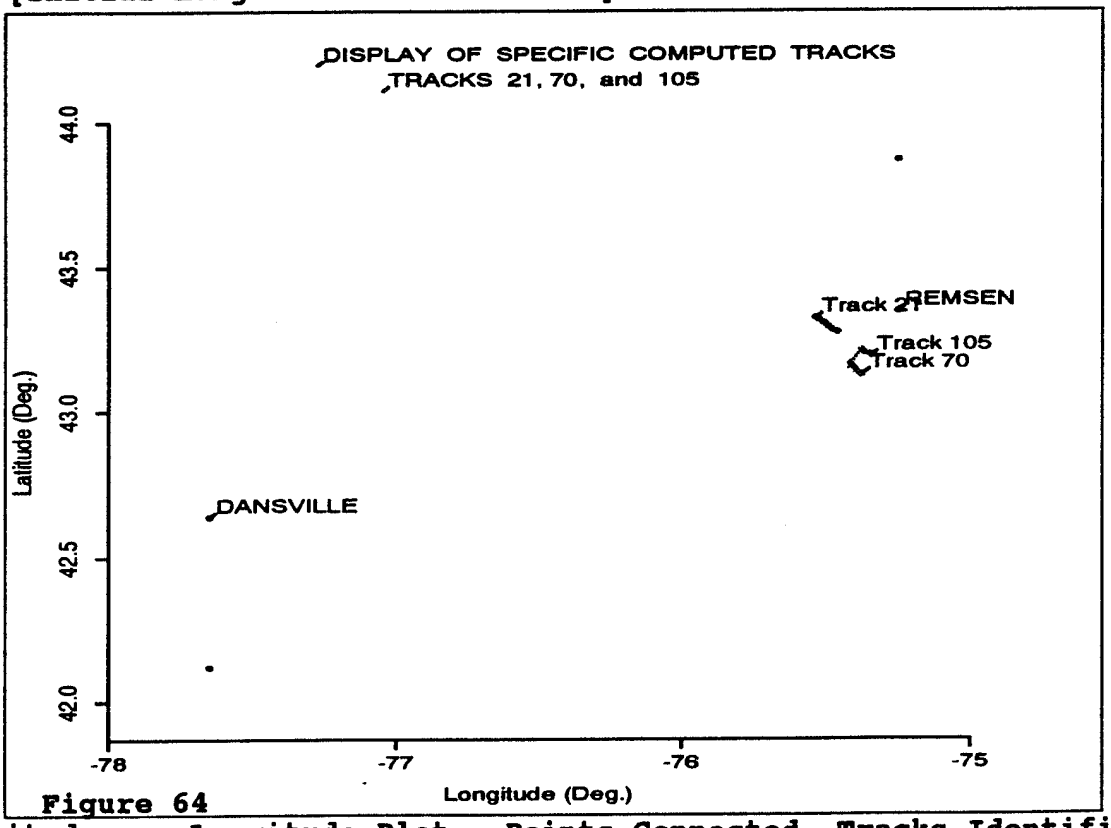


Figure 64

[Latitude vs. Longitude Plot - Points Connected, Tracks Identified]

TRACK DATA MENU: *Option 0* Continued

PLOT Tracks Submenu: *Option 4* - Continued

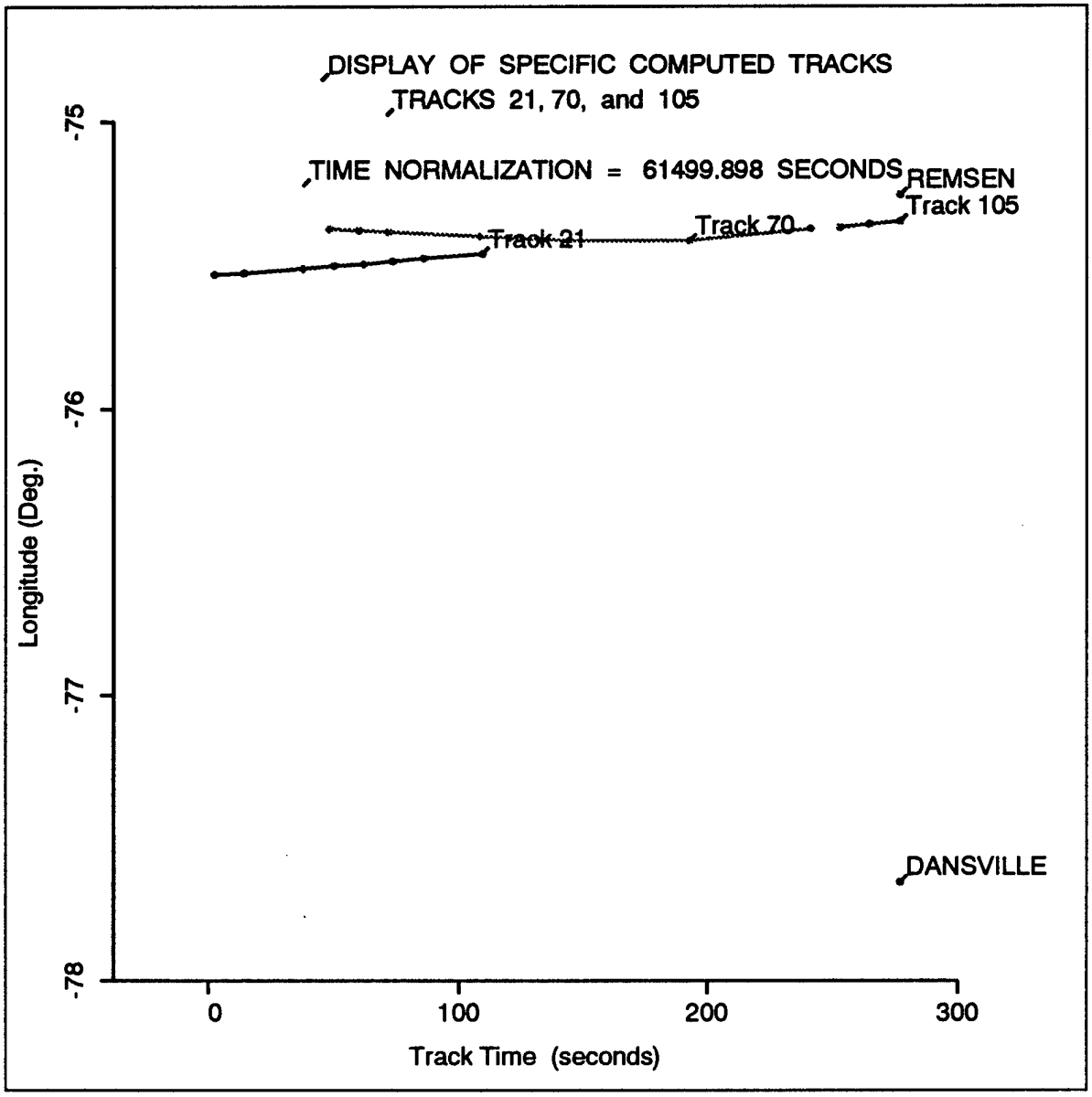


Figure 63(normalized)
[Initial Longitude vs. Time Plot]

Figure 66 is a repeat of **Figure 64** on page A-38 with the Aspect Ratio Points removed. The subset data menu used to remove the Points is shown as **Figure 65**.

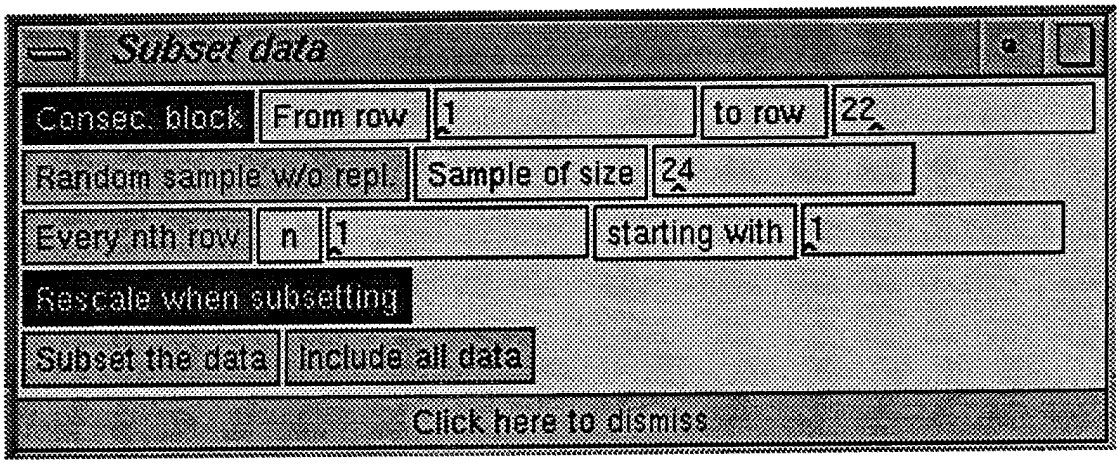


Figure 65

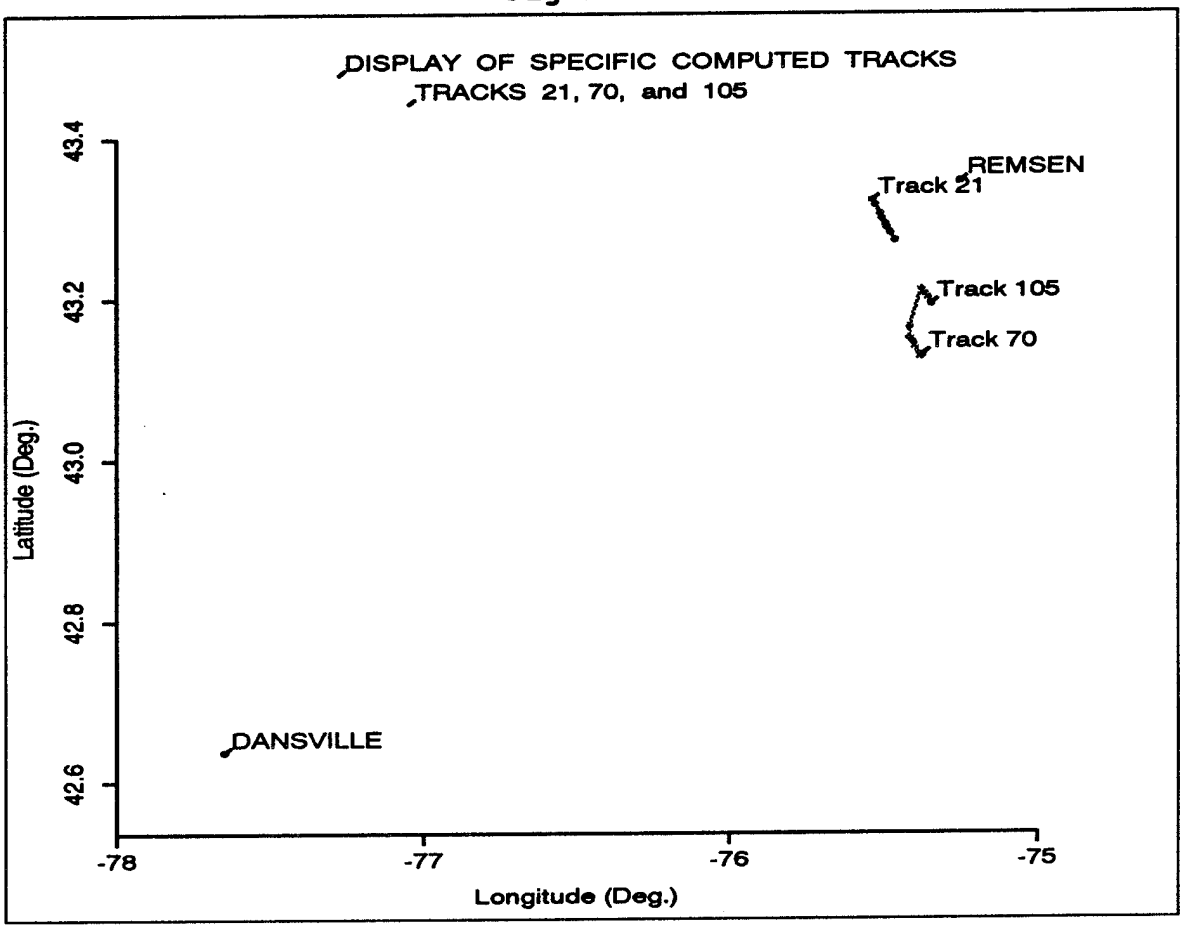


Figure 66
[Latitude vs. Longitude Plot - Aspect Ratio Points REMOVED]

TRACK DATA MENU: *Option 1*

```
Track Data MENU 2:
 0.  PLOT Tracks
 1.  Output Tables by Track Numbers containing Number of Associated Detections and:
     a.  Minimum time and Maximum time
     b.  Range of Track Coordinates
 2.  PLOT One Track
 3.  PLOT One Track and Associated Detections
 4.  PLOT Association Cost
 5.  COMPUTE TABULAR Summary of Innovation (Detections - Track) along with corresponding plot.
 6.  OUTPUT a Table of Target ID vs. Associated Tracks
 7.  PLOT Track Covariances vs. Time
 8.  PLOT Covariance Ellipses for Detections vs. Tracks
 9.  PRINT OUT (by time tick) Selected Data Corresponding to a Particular Track
10.  PLOT ALL Track Points Corresponding to a Particular Target ID
11.  PLOT Velocity by Track
12.  TRANSFER to Scan Data Menu
13.  QUIT
MENU Choice:  1
```

Figure 67

If the User chooses *Option 1.* from the menu above, a Table will be output which summarizes the Track data by Track Number. The Track Number and number of Associated Detects will be output followed by eight columns:

1. Minimum and Maximum time for each Track.
2. Minimum and Maximum Longitude for each Track.
3. Minimum and Maximum Latitude for each Track.
4. Minimum and Maximum Altitude for each Track

(**Figure 69** on page A-42)
and
(**Figure 69(normalized)** on page A-43)

After the Table is displayed in the User's shell, the following question (**Figure 68**) will be posed to offer the User a chance to obtain a **HARD COPY** of the Table:

```
**************************************************
Do you want to have a HARD COPY of the above TABLE?
     1)  YES
     2)  NO  [or push <Enter> TWO TIMES]
1
```

Figure 68

TRACK DATA MENU: *Option 1* Continued

Track #	# of Assoc. Detects	Time (Seconds) MIN.	Time (Seconds) MAX.	Longitude (Degrees) MIN.	Longitude (Degrees) MAX.	Latitude (Degrees) MIN.	Latitude (Degrees) MAX.	Altitude (kilometers) MIN.	Altitude (kilometers) MAX.
1	35	61499.9	61775.5	-76.04	-75.33	41.80	42.05	9.87	9.95
2	40	61500.3	61778.5	-76.81	-76.37	41.69	41.79	5.33	5.34
3	43	61500.3	61777.4	-76.05	-75.74	42.69	42.71	7.16	7.16
4	15	61500.3	61777.0	-75.73	-75.60	42.89	42.97	1.10	1.16
5	29	61500.3	61729.1	-77.19	-76.63	41.87	41.97	10.49	10.52
6	43	61500.6	61777.3	-77.27	-76.53	42.29	42.52	9.29	9.30
7	40	61500.6	61777.4	-76.92	-76.20	41.96	42.18	9.90	9.91
8	1	61500.7	61500.7	-76.37	-76.37	42.53	42.53	9.91	9.91
9	32	61500.7	61765.5	-77.32	-77.02	42.08	42.25	4.57	4.61
10	45	61500.9	61777.4	-76.63	-76.32	42.68	42.71	1.28	1.95
11	1	61500.9	61500.9	-77.33	-77.33	42.11	42.11	6.58	6.58
12	17	61500.9	61777.8	-76.32	-76.13	42.89	42.91	0.30	0.40
13	33	61501.4	61776.0	-77.26	-76.86	42.79	42.79	3.41	3.41
14	15	61501.4	61776.4	-76.03	-75.75	42.94	43.09	0.33	2.77
15	31	61501.7	61774.5	-77.59	-77.39	42.94	43.13	0.21	1.25
16	36	61501.6	61777.8	-76.22	-76.02	43.02	43.19	3.38	3.72
17	38	61501.7	61776.3	-76.39	-76.14	43.15	43.17	1.85	1.90
18	33	61501.8	61775.6	-77.45	-77.05	43.04	43.06	1.85	2.47
19	36	61501.8	61777.1	-75.70	-75.40	43.24	43.30	2.68	3.74
20	1	61501.8	61501.8	-75.95	-75.95	43.28	43.28	3.50	3.50
21	8	61501.8	61609.3	-75.53	-75.46	43.27	43.32	0.09	0.52
22	40	61502.9	61775.6	-77.02	-76.80	43.21	43.26	0.76	0.83
23	10	61503.0	61634.2	-75.86	-75.85	43.32	43.43	1.71	1.71
24	21	61503.0	61779.6	-75.99	-75.79	43.48	43.53	0.79	0.82
25	48	61503.1	61779.3	-76.24	-76.08	43.41	43.68	2.25	2.32
26	20	61504.0	61731.7	-75.94	-75.68	43.39	43.63	1.37	2.96
27	13	61504.3	61588.9	-75.88	-75.63	44.08	44.09	4.27	4.30
28	10	61505.1	61625.3	-75.55	-75.46	44.61	44.68	1.95	1.99
29	1	61508.1	61508.1	-75.30	-75.30	44.76	44.76	8.69	8.69
30	11	61501.7	61612.8	-77.65	-77.60	43.16	43.22	0.12	0.49
31	13	61501.8	61653.4	-77.42	-77.36	43.99	44.08	0.34	0.95
32	1	61503.0	61503.0	-76.81	-76.81	43.21	43.21	13.56	13.56
33	32	61503.0	61778.1	-76.74	-76.31	43.18	43.20	0.52	1.62
34	42	61504.3	61777.4	-76.69	-76.42	42.41	42.55	4.41	4.45
35	35	61504.3	61777.4	-76.14	-75.74	42.26	42.45	6.19	6.25
36	15	61504.3	61655.9	-75.44	-74.99	42.30	42.34	9.87	9.89
37	11	61504.4	61596.6	-76.30	-76.19	42.31	42.38	0.98	1.64
38	27	61504.7	61778.2	-77.18	-77.09	42.27	42.49	0.70	1.13
39	43	61504.7	61777.4	-76.64	-76.14	42.14	42.42	10.57	11.70
40	38	61504.7	61777.4	-76.29	-75.66	41.95	42.21	10.51	10.52
41	30	61504.6	61777.7	-75.78	-75.49	41.80	41.93	3.17	4.45
42	38	61504.7	61777.4	-77.02	-76.66	42.20	42.34	5.94	5.94
43	44	61505.0	61776.9	-76.73	-76.06	41.66	41.86	9.75	10.52
44	25	61505.1	61777.7	-77.00	-76.93	42.19	42.27	0.49	1.07
45	23	61505.1	61687.2	-75.99	-75.71	41.28	41.54	5.30	5.91
46	25	61505.4	61768.3	-77.17	-77.11	42.17	42.22	0.40	0.79
47	1	61511.2	61511.2	-75.26	-75.26	41.38	41.38	5.46	5.46
48	2	61511.1	61523.2	-75.28	-75.26	42.06	42.06	2.47	2.47
49	12	61511.4	61727.7	-75.52	-75.27	42.09	42.19	2.44	2.68
50	18	61512.6	61777.1	-75.67	-75.63	43.03	43.04	0.39	0.46
51	1	61512.9	61512.9	-77.36	-77.36	42.10	42.10	6.58	6.58
52	42	61513.9	61778.5	-76.77	-76.11	43.21	43.33	13.56	13.56
53	48	61514.0	61781.6	-75.95	-75.51	43.30	43.77	3.72	4.33
54	6	61515.8	61576.1	-76.36	-76.30	44.13	44.16	1.55	1.55
55	1	61517.5	61517.5	-75.27	-75.27	44.77	44.77	8.69	8.69
56	35	61513.6	61777.7	-75.66	-75.02	43.05	43.11	10.51	10.52
57	39	61514.3	61777.0	-76.33	-75.53	42.51	42.53	9.90	9.91
58	11	61521.6	61642.9	-77.65	-77.57	44.09	44.14	0.25	1.31
59	15	61525.4	61777.8	-76.14	-76.13	42.86	42.99	0.30	0.37
60	11	61525.0	61753.7	-76.09	-75.90	43.04	43.05	0.53	1.25

Figure 69

TRACK DATA MENU: *Option 1* Continued

Track #	# of Assoc. Detects	Time (Seconds) MIN.	Time (Seconds) MAX.	Longitude (Degrees) MIN.	Longitude (Degrees) MAX.	Latitude (Degrees) MIN.	Latitude (Degrees) MAX.	Altitude (kilometers) MIN.	Altitude (kilometers) MAX.
1	35	0.0	275.6	-76.04	-75.33	41.80	42.05	9.87	9.95
2	40	0.4	278.6	-76.81	-76.37	41.69	41.79	5.33	5.34
3	43	0.4	277.5	-76.05	-75.74	42.69	42.71	7.16	7.16
4	15	0.4	277.1	-75.73	-75.60	42.89	42.97	1.10	1.16
5	29	0.4	229.2	-77.19	-76.63	41.87	41.97	10.49	10.52
6	43	0.7	277.4	-77.27	-76.53	42.29	42.52	9.29	9.30
7	40	0.7	277.5	-76.92	-76.20	41.96	42.18	9.90	9.91
8	1	0.8	0.8	-76.37	-76.37	42.53	42.53	9.91	9.91
9	32	0.8	265.6	-77.32	-77.02	42.08	42.25	4.57	4.61
10	45	1.0	277.5	-76.63	-76.32	42.68	42.71	1.28	1.95
11	1	1.0	1.0	-77.33	-77.33	42.11	42.11	6.58	6.58
12	17	1.0	277.9	-76.32	-76.13	42.89	42.91	0.30	0.40
13	33	1.5	276.1	-77.26	-76.86	42.79	42.79	3.41	3.41
14	15	1.5	276.5	-76.03	-75.75	42.94	43.09	0.33	2.77
15	31	1.8	274.6	-77.59	-77.39	42.94	43.13	0.21	1.25
16	36	1.7	277.9	-76.22	-76.02	43.02	43.19	3.38	3.72
17	38	1.8	276.4	-76.39	-76.14	43.15	43.17	1.85	1.90
18	33	1.9	275.7	-77.45	-77.05	43.04	43.06	1.85	2.47
19	36	1.9	277.2	-75.70	-75.40	43.24	43.30	2.68	3.74
20	1	1.9	1.9	-75.95	-75.95	43.28	43.28	3.50	3.50
21	8	1.9	109.4	-75.53	-75.46	43.27	43.32	0.09	0.52
22	40	3.0	275.7	-77.02	-76.80	43.21	43.26	0.76	0.83
23	10	3.1	134.3	-75.86	-75.85	43.32	43.43	1.71	1.71
24	21	3.1	279.7	-75.99	-75.79	43.48	43.53	0.79	0.82
25	48	3.2	279.4	-76.24	-76.08	43.41	43.68	2.25	2.32
26	20	4.1	231.8	-75.94	-75.68	43.39	43.63	1.37	2.96
27	13	4.4	89.0	-75.88	-75.63	44.08	44.09	4.27	4.30
28	10	5.2	125.4	-75.55	-75.46	44.61	44.68	1.95	1.99
29	1	8.2	8.2	-75.30	-75.30	44.76	44.76	8.69	8.69
30	11	1.8	112.9	-77.65	-77.60	43.16	43.22	0.12	0.49
31	13	1.9	153.5	-77.42	-77.36	43.99	44.08	0.34	0.95
32	1	3.1	3.1	-76.81	-76.81	43.21	43.21	13.56	13.56
33	32	3.1	278.2	-76.74	-76.31	43.18	43.20	0.52	1.62
34	42	4.4	277.5	-76.69	-76.42	42.41	42.55	4.41	4.45
35	35	4.4	277.5	-76.14	-75.74	42.26	42.45	6.19	6.25
36	15	4.4	156.0	-75.44	-74.99	42.30	42.34	9.87	9.89
37	11	4.5	96.7	-76.30	-76.19	42.31	42.38	0.98	1.64
38	27	4.8	278.3	-77.18	-77.09	42.27	42.49	0.70	1.13
39	43	4.8	277.5	-76.64	-76.14	42.14	42.42	10.57	11.70
40	38	4.8	277.5	-76.29	-75.66	41.95	42.21	10.51	10.52
41	30	4.7	277.8	-75.78	-75.49	41.80	41.93	3.17	4.45
42	38	4.8	277.5	-77.02	-76.66	42.20	42.34	5.94	5.94
43	44	5.1	277.0	-76.73	-76.06	41.66	41.86	9.75	10.52
44	25	5.2	277.8	-77.00	-76.93	42.19	42.27	0.49	1.07
45	23	5.2	187.3	-75.99	-75.71	41.28	41.54	5.30	5.91
46	25	5.5	268.4	-77.17	-77.11	42.17	42.22	0.40	0.79
47	1	11.3	11.3	-75.26	-75.26	41.38	41.38	5.46	5.46
48	2	11.2	23.3	-75.28	-75.26	42.06	42.06	2.47	2.47
49	12	11.5	227.8	-75.52	-75.27	42.09	42.19	2.44	2.68
50	18	12.7	277.2	-75.67	-75.63	43.03	43.04	0.39	0.46
51	1	13.0	13.0	-77.36	-77.36	42.10	42.10	6.58	6.58
52	42	14.0	278.6	-76.77	-76.11	43.21	43.33	13.56	13.56
53	48	14.1	281.7	-75.95	-75.51	43.30	43.77	3.72	4.33
54	6	15.9	76.2	-76.36	-76.30	44.13	44.16	1.55	1.55
55	1	17.6	17.6	-75.27	-75.27	44.77	44.77	8.69	8.69
56	35	13.7	277.8	-75.66	-75.02	43.05	43.11	10.51	10.52
57	39	14.4	277.1	-76.33	-75.53	42.51	42.53	9.90	9.91
58	11	21.7	143.0	-77.65	-77.57	44.09	44.14	0.25	1.31
59	15	25.5	277.9	-76.14	-76.13	42.86	42.99	0.30	0.37
60	11	25.1	253.8	-76.09	-75.90	43.04	43.05	0.53	1.25

Figure 69(normalized)

TRACK DATA MENU: *Option 2*

```
Track Data MENU 2:
  0.  PLOT Tracks
  1.  Output Tables by Track Numbers containing Number of Associated Detections and:
      a.  Minimum time and Maximum time
      b.  Range of Track Coordinates
  2.  PLOT One Track
  3.  PLOT One Track and Associated Detections
  4.  PLOT Association Cost
  5.  COMPUTE TABULAR Summary of Innovation (Detections - Track) along with corresponding plot.
  6.  OUTPUT a Table of Target ID vs. Associated Tracks
  7.  PLOT Track Covariances vs. Time
  8.  PLOT Covariance Ellipses for Detections vs. Tracks
  9.  PRINT OUT (by time tick) Selected Data Corresponding to a Particular Track
 10.  PLOT ALL Track Points Corresponding to a Particular Target ID
 11.  PLOT Velocity by Track
 12.  TRANSFER to Scan Data Menu
 13.  QUIT
MENU Choice:  2
```

Figure 70

```
**************************************************
INPUT Track Number to be Viewed:  5
**************************************************
```

Figure 71

```
SENSOR Display Submenu:
  1.  PLOT Location of Dansville ONLY
  2.  PLOT Location of Remsen ONLY
  3.  PLOT Locations of ALL Sensors
  4.  DO NOT PLOT Location of Any Sensor

SENSOR Display Submenu Choice:  3
```

Figure 24 - Repeated

Option 2. **PLOT One Track** allows the User to plot the Track points for a given computed Track. After inputting the desired Track Number (**Figure 71**) and **SENSOR Display** choice (**Figure 24 - Repeated**), **Figure 72** on page A-45 (or **Figure 72(normalized)** on page A-46) occurs as a result of these INPUTS.

The axes are changed to "Longitude" and "Latitude" , the scatter plot points are connected, and the ASPECT RATIO points are removed from the data set in order to obtain the plot of **Figure 73.**

TRACK DATA MENU: *Option 2* Continued

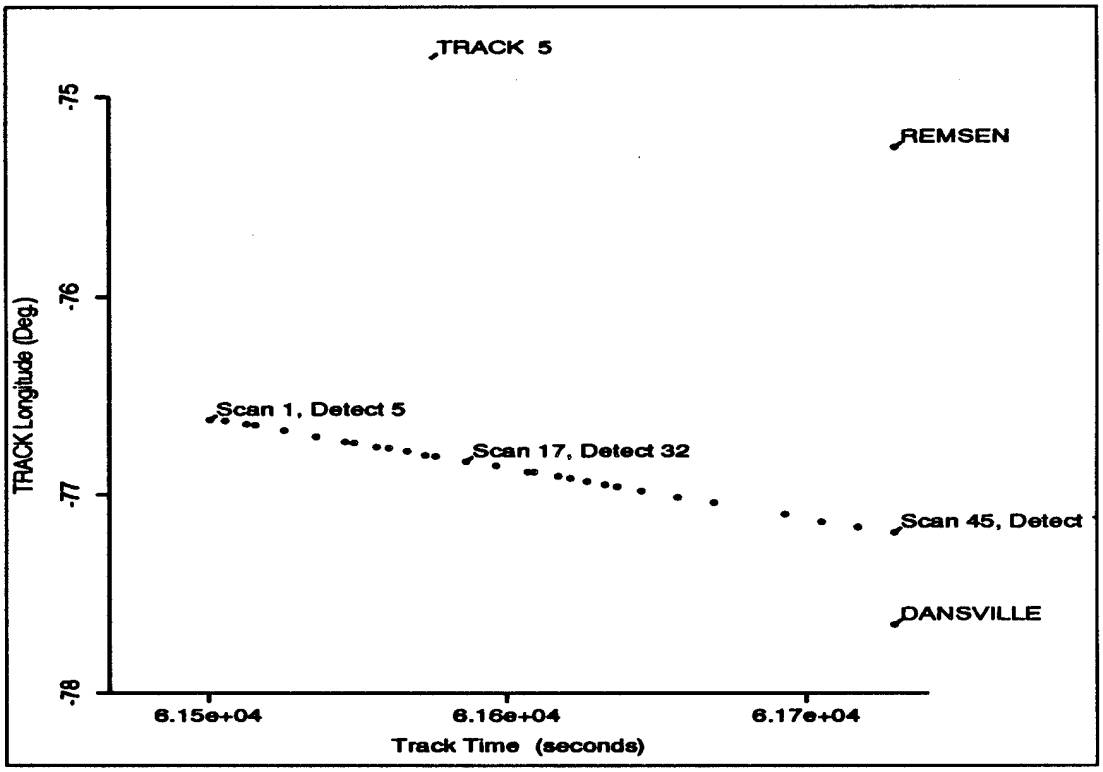


Figure 72
[Initial Longitude vs. Time Plot]

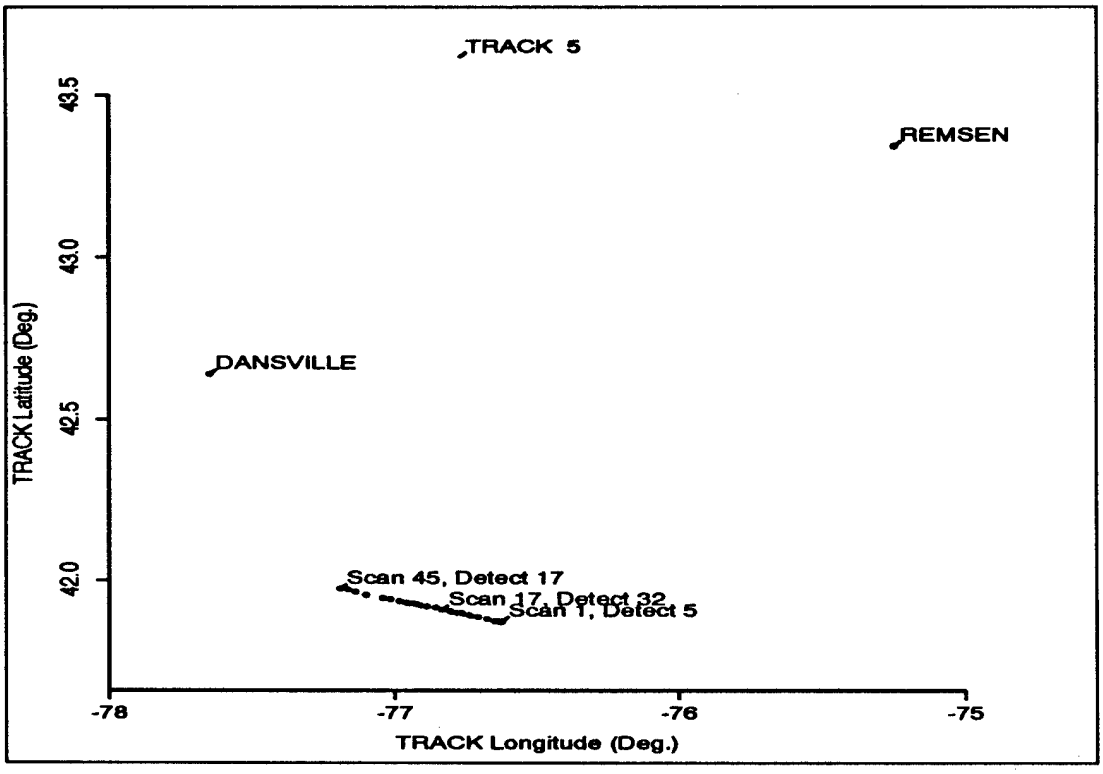


Figure 73
[Latitude vs. Longitude Plot - Aspect Ratio Points REMOVED]

TRACK DATA MENU: *Option 2* Continued

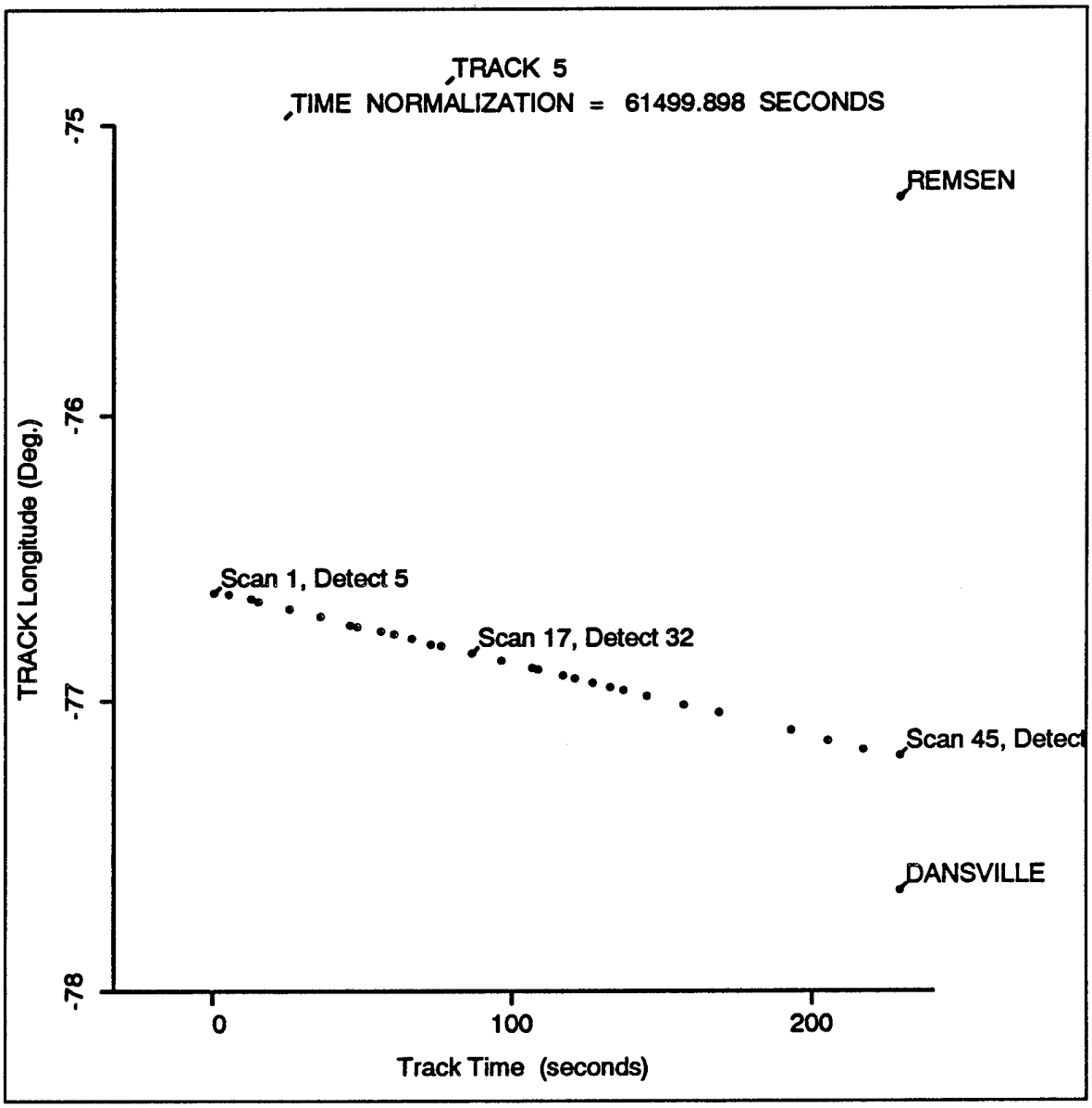


Figure 72(normalized)
[Initial Longitude vs. Time Plot]

TRACK DATA MENU: *Option 3*

```
Track Data MENU 2:
  0.  PLOT Tracks
  1.  Output Tables by Track Numbers containing Number of Associated Detections and:
      a.  Minimum time and Maximum time
      b.  Range of Track Coordinates
  2.  PLOT One Track
  3.  PLOT One Track and Associated Detections
  4.  PLOT Association Cost
  5.  COMPUTE TABULAR Summary of Innovation (Detections - Track) along with corresponding plot.
  6.  OUTPUT a Table of Target ID vs. Associated Tracks
  7.  PLOT Track Covariances vs. Time
  8.  PLOT Covariance Ellipses for Detections vs. Tracks
  9.  PRINT OUT (by time tick) Selected Data Corresponding to a Particular Track
 10.  PLOT ALL Track Points Corresponding to a Particular Target ID
 11.  PLOT Velocity by Track
 12.  TRANSFER to Scan Data Menu
 13.  QUIT
MENU Choice:  3
```

Figure 74

```
**************************************************
INPUT Track Number to be Viewed:  5
**************************************************
```

Figure 75

```
SENSOR Display Submenu:
  1.  PLOT Location of Dansville ONLY
  2.  PLOT Location of Remsen ONLY
  3.  PLOT Locations of ALL Sensors
  4.  DO NOT PLOT Location of Any Sensor

SENSOR Display Submenu Choice:  3
```

Figure 24 - Repeated

Option 3 (**Figure 74**) allows the User to obtain a plot of a given Track along with the Associated Input Detections used to develop that Track. The Inputs shown above result in **Figure 76** on page A-48 or **Figure 76(normalized)** on page A-49. **Figure 77** on page A-48 is a plot of this case with axes changed to Latitude and Longitude and Sensor locations and Aspect Ratio points both included.

TRACK DATA MENU: *Option 3* Continued

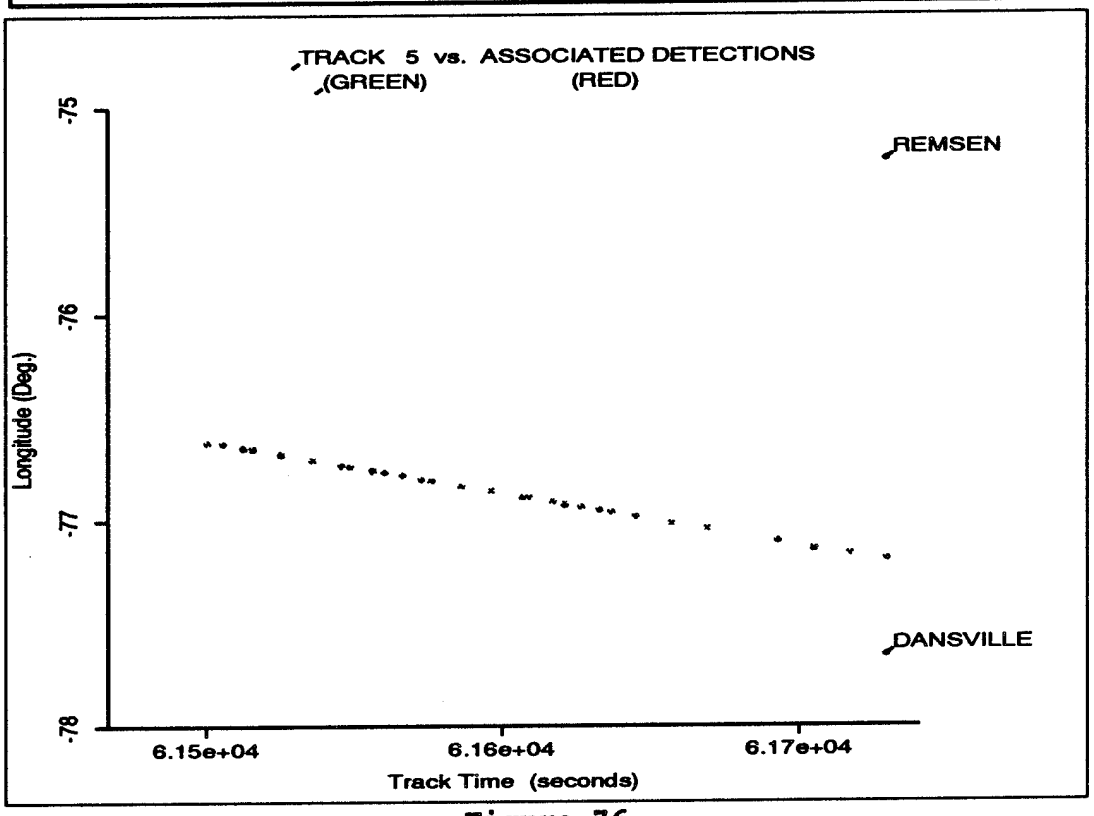


Figure 76
[Initial Longitude vs. Time Plot]

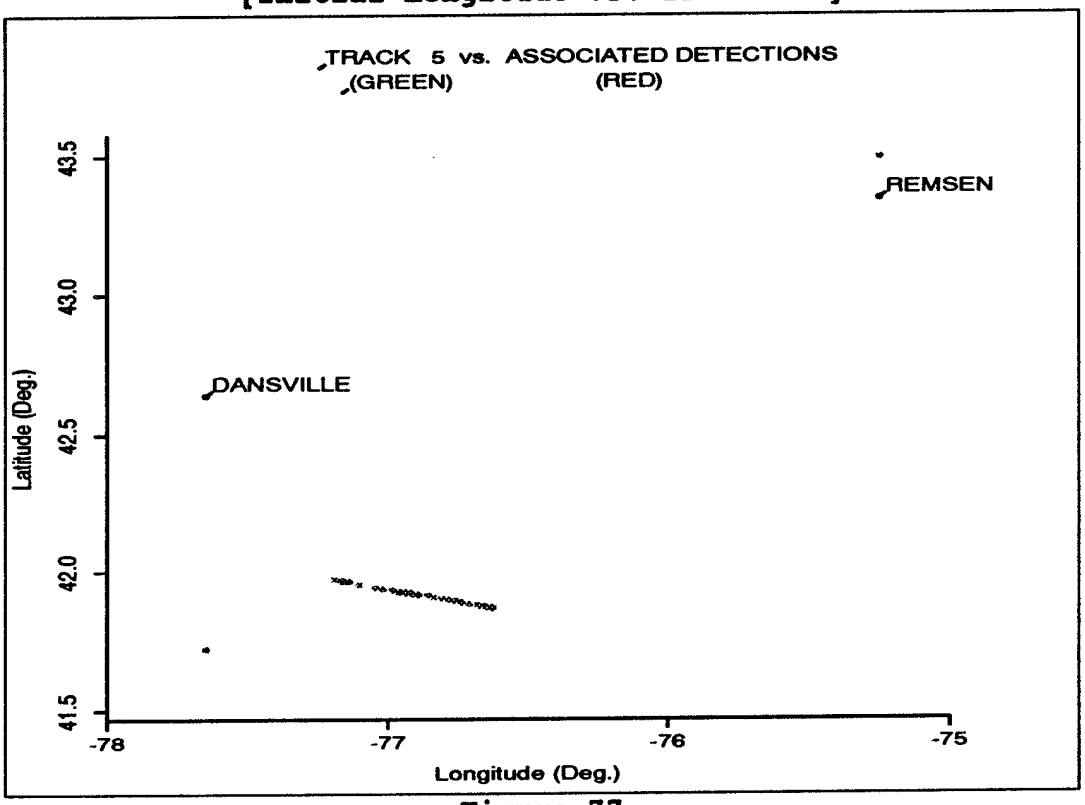


Figure 77
[Latitude vs. Longitude Plot]

TRACK DATA MENU: *Option 3* Continued

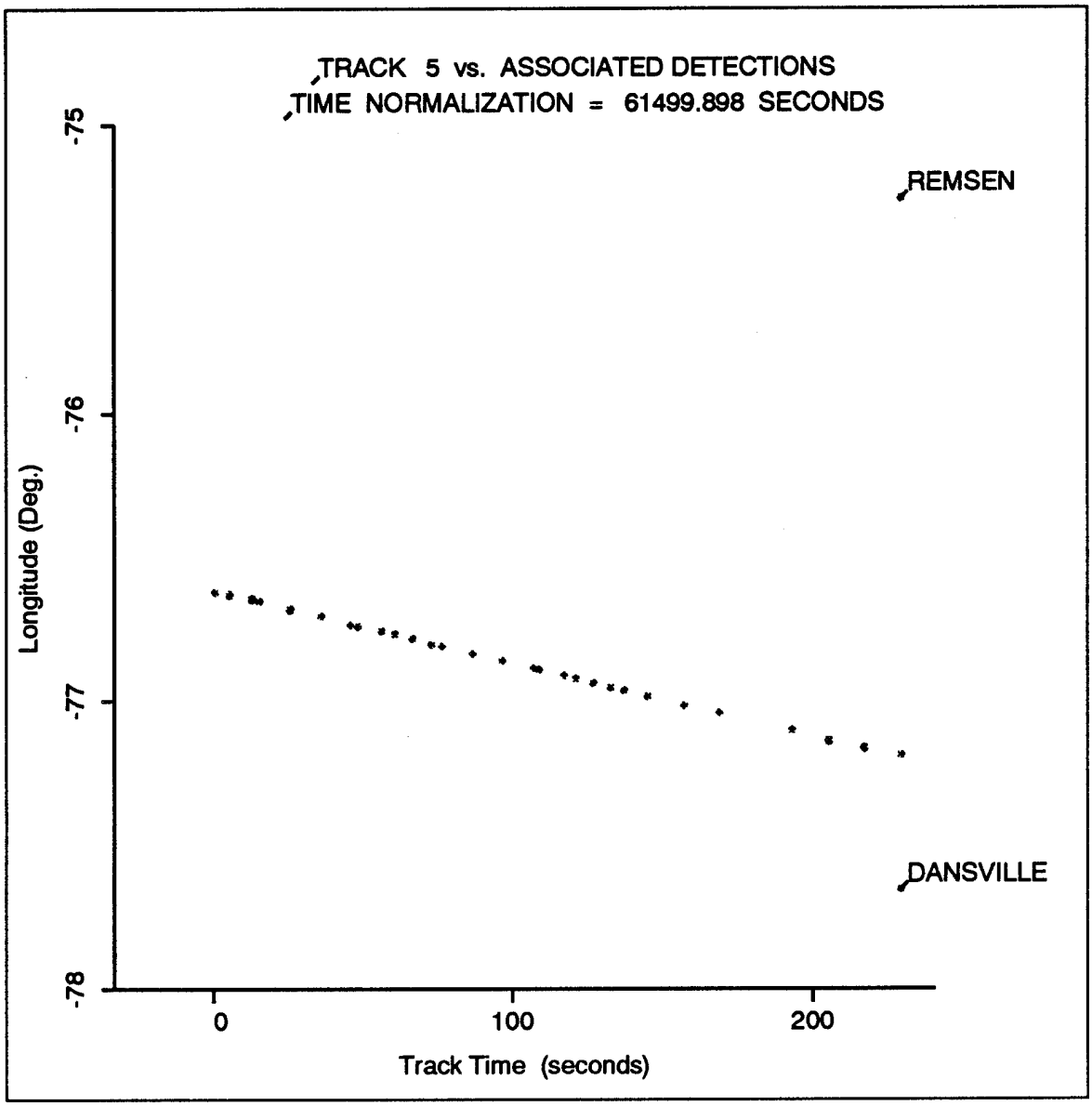


Figure 76(normalized)
[Initial Longitude vs. Time Plot]

TRACK DATA MENU: *Option 3* Continued

Occasionally, including the Sensor locations in a plot may make it difficult to analyze what is happening with a particular Track even though the Aspect Ratio points have been removed. In this case, the data may be rerun **without** requesting the Sensor locations or the Subset data menu may be accessed and the last four points removed (**Figure 78**) so as to remove both the Sensor location points and Aspect Ratio points (**Figure 79**).

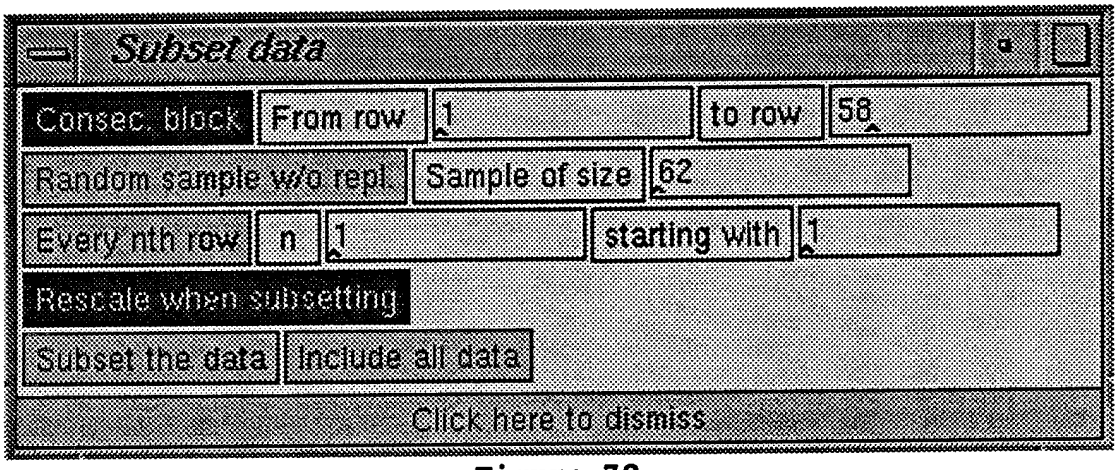


Figure 78

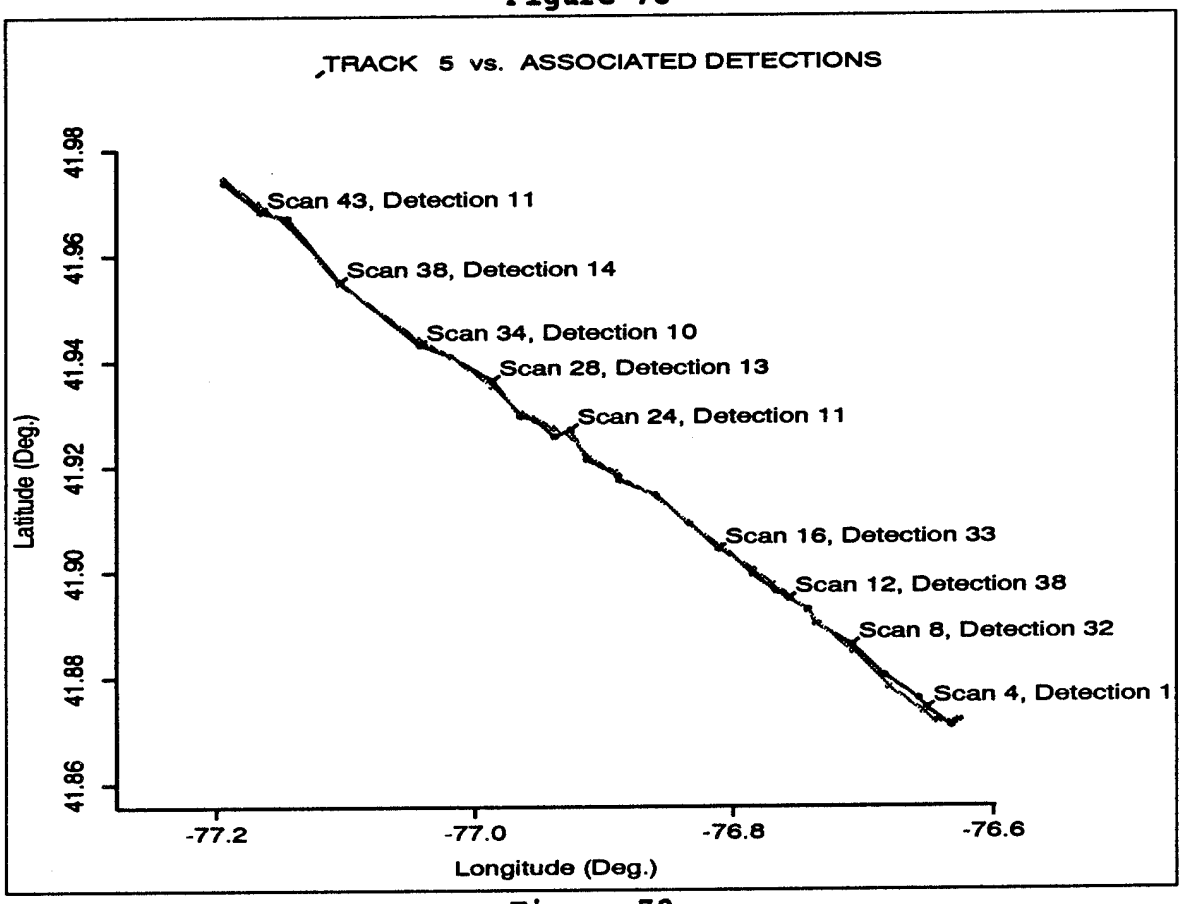


Figure 79
["Aspect Ratio" and Sensor points removed from Figure 77]

TRACK DATA MENU: *Option 4*

```
Track Data MENU 2:
  0.  PLOT Tracks
  1.  Output Tables by Track Numbers containing Number of Associated Detections and:
      a.  Minimum time and Maximum time
      b.  Range of Track Coordinates
  2.  PLOT One Track
  3.  PLOT One Track and Associated Detections
  4.  PLOT Association Cost
  5.  COMPUTE TABULAR Summary of Innovation (Detections - Track) along with corresponding plot.
  6.  OUTPUT a Table of Target ID vs. Associated Tracks
  7.  PLOT Track Covariances vs. Time
  8.  PLOT Covariance Ellipses for Detections vs. Tracks
  9.  PRINT OUT (by time tick) Selected Data Corresponding to a Particular Track
 10.  PLOT ALL Track Points Corresponding to a Particular Target ID
 11.  PLOT Velocity by Track
 12.  TRANSFER to Scan Data Menu
 13.  QUIT
MENU Choice:  4
```

Figure 80

```
**************************************************
Plot Cost MENU:
  1.  For a single track
  2.  Across all tracks
Plot Cost MENU Choice:  1
**************************************************
```

Figure 81

```
******************************************************
When plotting COST, does the User also want to have the MEAN COST plotted?
     1.  YES
     2.  NO
MEAN Plotting Choice:  1
******************************************************
```

Figure 82

Option 4 from the **Track Data MENU 2** is to **PLOT Association Cost** (**Figure 80**). After making this choice, the User will then have the *Option* (**Figure 81**) to plot the cost for a single track or across all tracks. Both choices will be illustrated below.

If the choice is for a single track, the User will then be asked if the MEAN COST for that Track should also be plotted (**Figure 82**).

TRACK DATA MENU: *Option 4* Continued

At the same time that the MEAN COST is being computed, the Standard Deviation of that Cost is also being calculated. Therefore, if the answer to the query of **Figure 82** on page A-51 is **YES**, then the User will be asked if he/she would like to have lines plotted around the MEAN line which represent a particular number of standard deviations around the MEAN (**Figure 83**). [For this example, the response is "**0**" or DO NOT PLOT Standard Deviations around the MEAN.]

Finally, the Track Number to be viewed is requested (**Figure 84**).

The plots which result from these responses are on pages A-53 and A-54 (**normalized times**).

```
**********************************************************
COST and the MEAN COST will be plotted.

Does the User also want to have the Standard Deviations plotted around the MEAN COST?
    0.  DO NOT PLOT Standard Deviations around the MEAN
    1.  +/- One Standard Deviation    (If Normality Assumed, should include 68.3 per cent of the Data)
    2.  +/- Two Standard Deviations   (If Normality Assumed, should include 95.4 per cent of the Data)
    3.  +/- Three Standard Deviations (If Normality Assumed, should include 99.73 per cent of the Data)
Standard Deviation Choice:  0
**********************************************************
```

Figure 83

```
**************************************************
INPUT Track Number to be Viewed:  5
**************************************************
```

Figure 84

TRACK DATA MENU: *Option 4* Continued

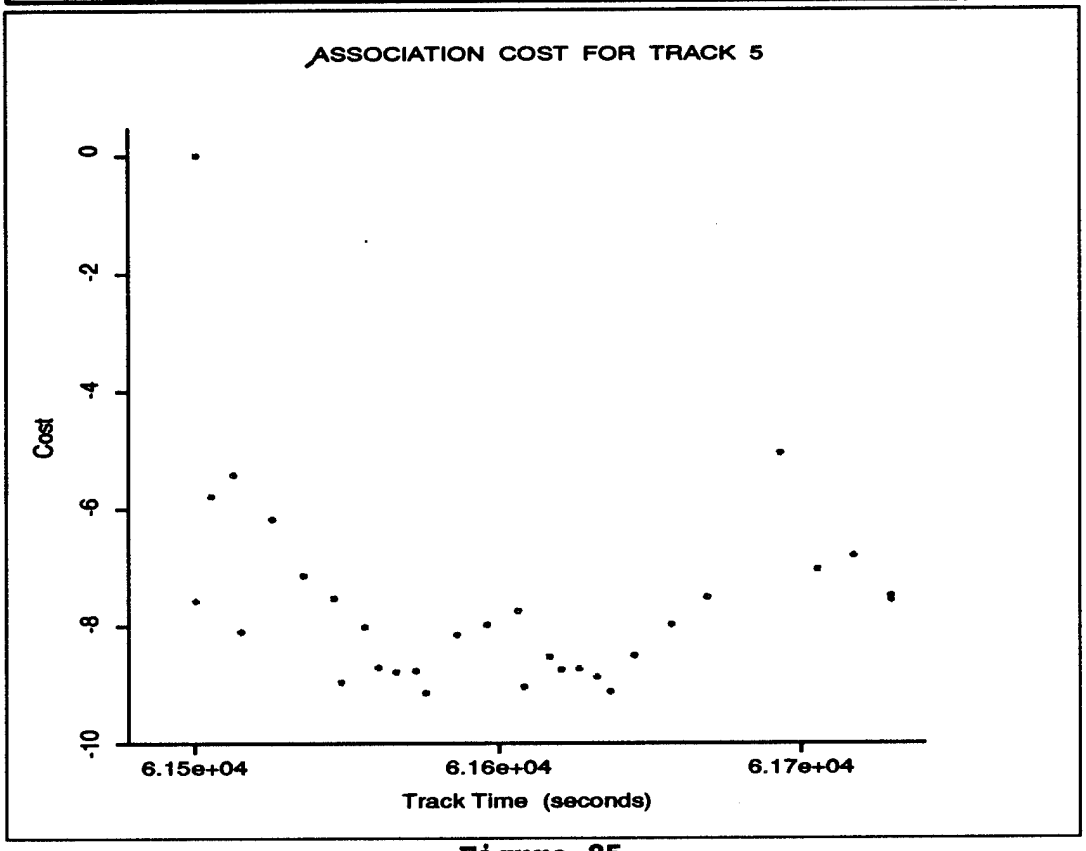


Figure 85

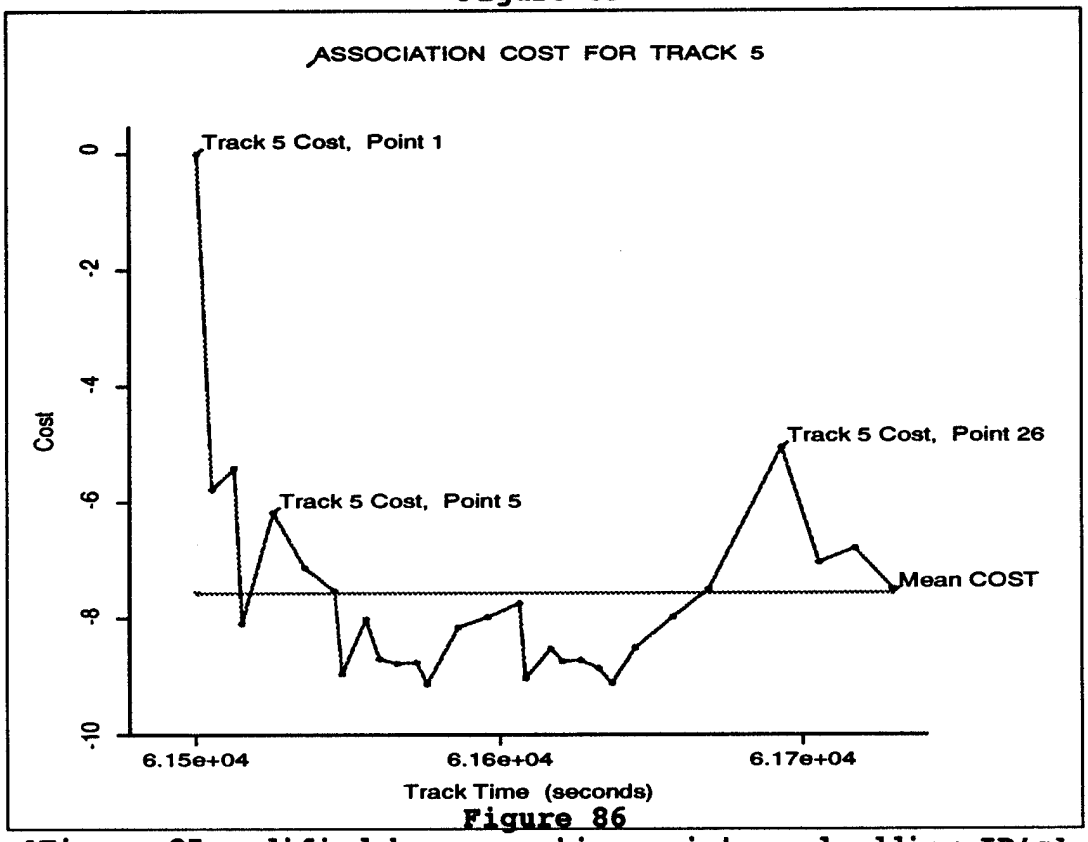


Figure 86

[Figure 85 modified by connecting points and adding ID's]

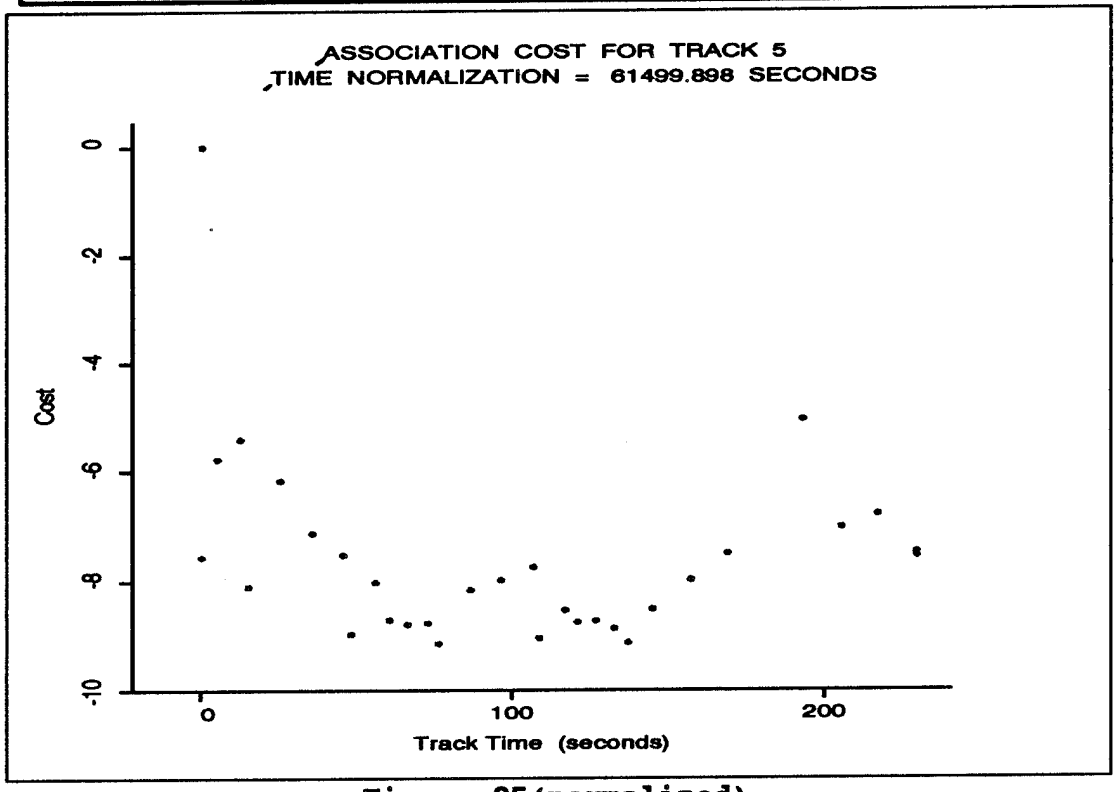


Figure 85(normalized)

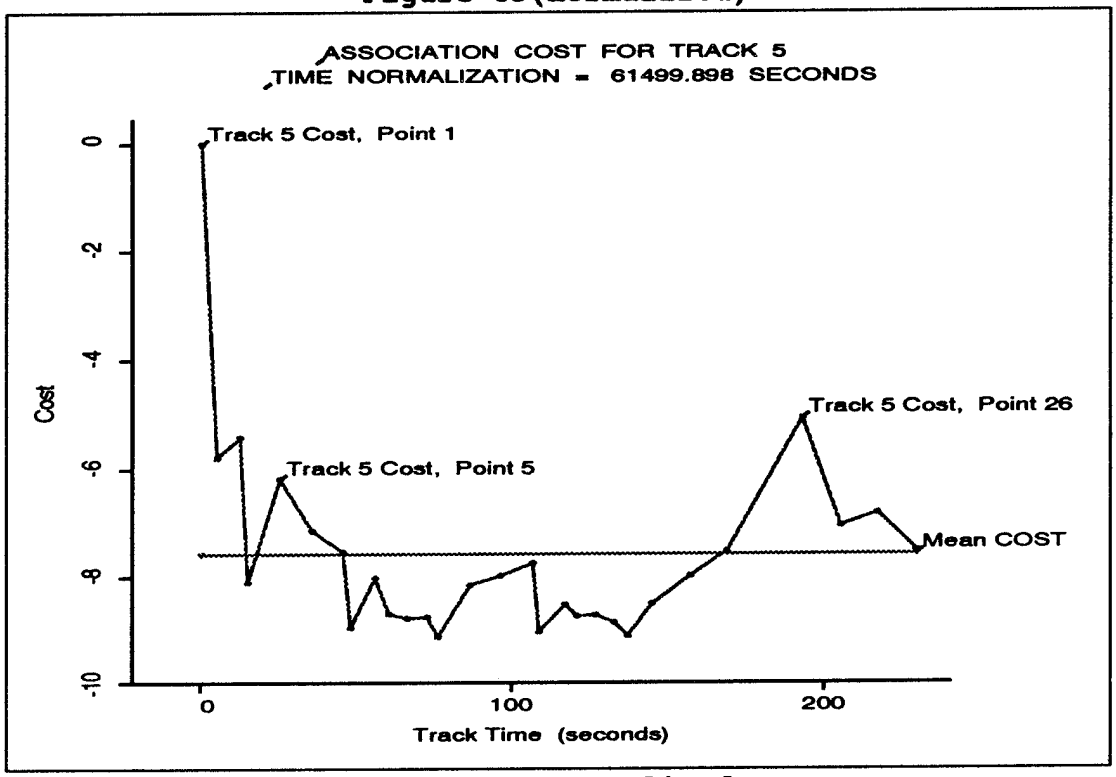


Figure 86(normalized)
[Figure 85(normalized) <u>modified</u> by connecting points and adding ID's]

TRACK DATA MENU: *Option 4* Continued

If, from **Figure 83** on page A-52, the User had chosen to plot the standard deviation of the cost for Track 5 around the mean value, the plot of **Figure 88** would have been the result (after connecting the points in the initial scatter plot and adding labels). The plot on page A-56 (**Figure 88(normalized)** is the same as **Figure 88** but with the times normalized to the initial Detection time.

```
**************************************************
COST and the MEAN COST will be plotted.

Does the User also want to have the Standard Deviations plotted around the MEAN COST?
    0.  DO NOT PLOT Standard Deviations around the MEAN
    1.  +/- One Standard Deviation    (If Normality Assumed, should include 68.3 per cent of the Data)
    2.  +/- Two Standard Deviations   (If Normality Assumed, should include 95.4 per cent of the Data)
    3.  +/- Three Standard Deviations (If Normality Assumed, should include 99.73 per cent of the Data)
Standard Deviation Choice:  1
**************************************************
```

Figure 87

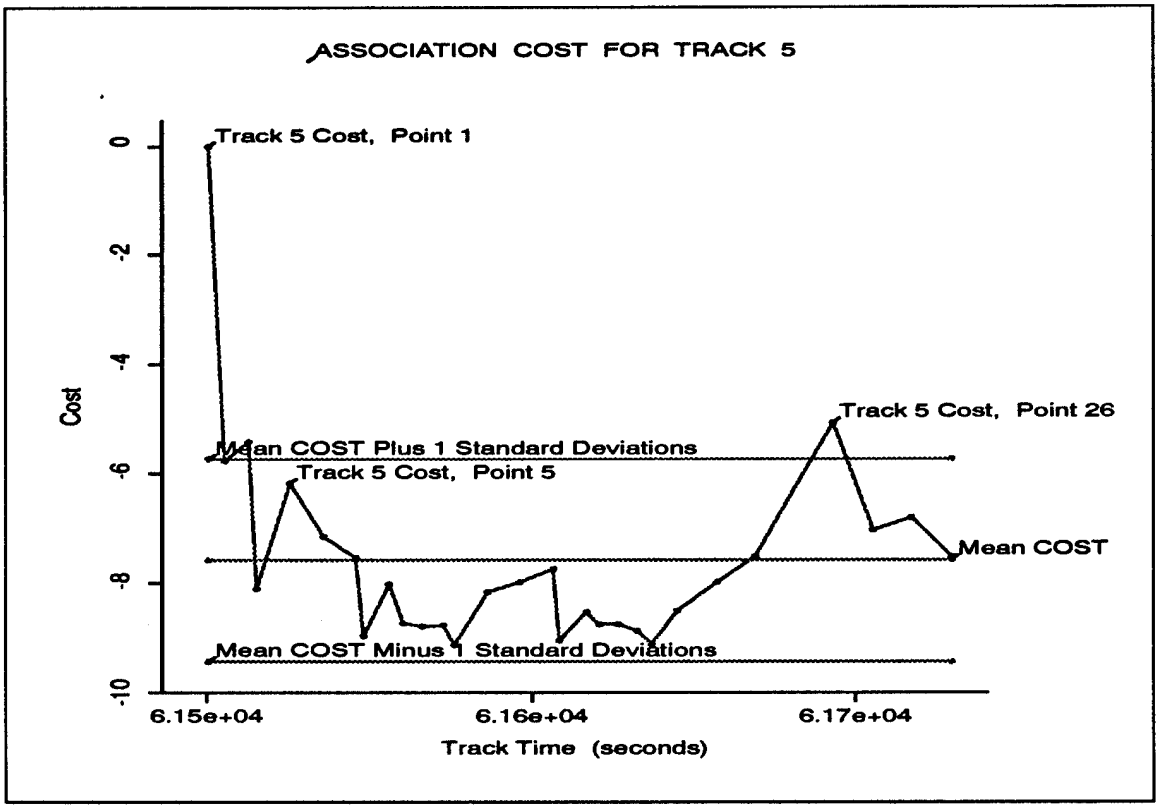


Figure 88

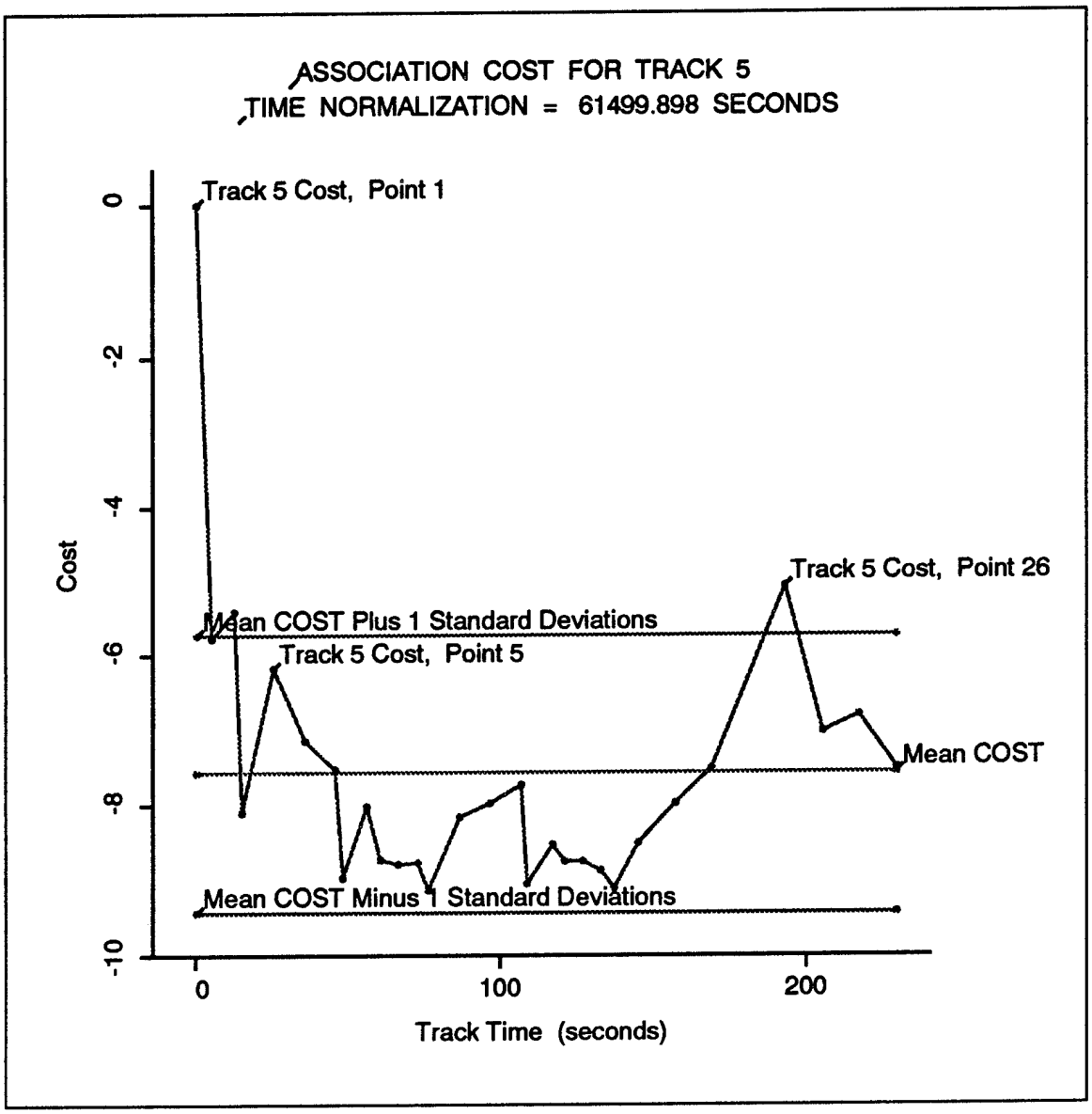


Figure 88(normalized)

TRACK DATA MENU: *Option 4* Continued

```
Track Data MENU 2:
  0.  PLOT Tracks
  1.  Output Tables by Track Numbers containing Number of Associated Detections and:
      a.  Minimum time and Maximum time
      b.  Range of Track Coordinates
  2.  PLOT One Track
  3.  PLOT One Track and Associated Detections
  4.  PLOT Association Cost
  5.  COMPUTE TABULAR Summary of Innovation (Detections - Track) along with corresponding plot.
  6.  OUTPUT a Table of Target ID vs. Associated Tracks
  7.  PLOT Track Covariances vs. Time
  8.  PLOT Covariance Ellipses for Detections vs. Tracks
  9.  PRINT OUT (by time tick) Selected Data Corresponding to a Particular Track
 10.  PLOT ALL Track Points Corresponding to a Particular Target ID
 11.  PLOT Velocity by Track
 12.  TRANSFER to Scan Data Menu
 13.  QUIT
MENU Choice:  4
```

Figure 80 – Repeated

```
**************************************************
Plot Cost MENU:
   1.  For a single track
   2.  Across all tracks
Plot Cost MENU Choice:  2
**************************************************
```

Figure 89

```
******************************************************
MEAN COST for each track will be plotted.

Does the User also want to have the Standard Deviations plotted around the MEAN COST?
    0.  DO NOT PLOT Standard Deviations around the MEAN
    1.  +/- One Standard Deviation    (If Normality Assumed, should include 68.3 per cent of the Data)
    2.  +/- Two Standard Deviations   (If Normality Assumed, should include 95.4 per cent of the Data)
    3.  +/- Three Standard Deviations (If Normality Assumed, should include 99.73 per cent of the Data)
Standard Deviation Choice:  0
******************************************************
```

Figure 90

If the User chooses to PLOT Association COST and then chooses *Option 2* from the Plot Cost MENU, the MEAN COST for each track will be plotted. Also, immediately upon responding to the query of **Figure 90**, a Table of Track Number, Number of Associated Detections, Mean Association COST for the given Track, and Standard Deviation of the COST for the given Track, are output to the User's shell (**Figure 91** on page A-58) and may be printed out by answering "Yes" to the usual Hard Copy question.

Figure 92 on page A-59 results from this choice of *Option 4* (after connecting the points in the initial scatter plot).

Figure 93 on page A-59 results from choosing *Option 1.* from the menu of **Figure 90** (and adding labels to the curves).

TRACK DATA MENU: *Option 4* Continued

Track Number	Number of Associated Detects	Mean Association COST	Standard Deviation COST
1	35	-6.639184	1.607926
2	40	-7.499599	1.640196
3	43	-7.917850	1.539668
4	15	-5.355937	2.477244
5	29	-7.581075	1.842380
6	43	-8.343904	1.789928
7	40	-7.647549	1.921407
9	32	-6.937297	1.781929
10	45	-7.970737	1.507958
12	17	-6.115903	2.780618
13	33	-7.874172	1.870390
14	15	-5.182754	3.063863
15	31	-7.274426	1.852525
16	36	-7.016156	1.409667
17	38	-7.021727	1.592505
18	33	-7.685291	1.958046
19	36	-7.355974	1.953724
21	8	-6.199631	3.285765
22	40	-8.116442	1.563570
23	10	-5.585039	2.769777
24	21	-7.319962	2.132530
25	48	-7.819836	1.650652
26	20	-5.901803	2.477857
27	13	-6.893498	2.873656
28	10	-6.029074	2.550431
30	11	-6.461277	2.407237
31	13	-5.675668	2.043477
33	32	-7.281401	2.384048
34	42	-8.078735	1.596051
35	35	-7.159513	1.645775
36	15	-5.750535	2.203432
37	11	-6.530680	2.550221
38	27	-7.246177	1.690723
39	43	-8.035809	1.590716
40	38	-7.513459	1.703038
41	30	-6.833278	2.059210
42	38	-7.819946	1.761334
43	44	-7.772551	1.622277
44	25	-6.870125	1.653902
45	23	-6.738566	1.886586
46	25	-6.970666	1.675538
48	2	-1.447251	2.046722
49	12	-5.000810	2.390260
50	18	-6.590872	2.697541
52	42	-7.355531	2.466799
53	48	-7.545585	2.139042
54	6	-5.591600	3.230623
56	35	-6.672262	2.091456
57	39	-7.765274	1.792487
58	11	-5.562553	2.280005
59	15	-5.759603	2.696463
60	11	-4.546228	3.002024
61	32	-7.983765	2.055153
62	3	-2.673825	3.030881
63	26	-6.666516	2.433055
64	18	-6.849485	2.720226
69	24	-6.584076	1.933577
70	9	-4.470470	3.876206
72	2	-3.420602	4.837461
73	25	-6.358548	2.281986
75	26	-6.949069	2.130296
76	14	-6.181808	2.341125
77	32	-6.828402	2.253836
83	15	-6.617152	2.012546
85	2	-1.950882	2.758964
87	4	-3.600949	3.471792
88	14	-5.156883	2.735796
92	10	-5.000189	2.388390
94	7	-4.502557	2.754561
95	4	-1.600140	2.049951
96	4	-2.049621	2.883010
101	4	-4.188647	2.920286
102	6	-4.371143	2.683885
104	4	-4.467777	3.662047
105	3	-3.804519	3.620561
107	3	-3.511722	3.431201
109	2	-1.899765	2.686673

Figure 91

TRACK DATA MENU: *Option 4* Continued

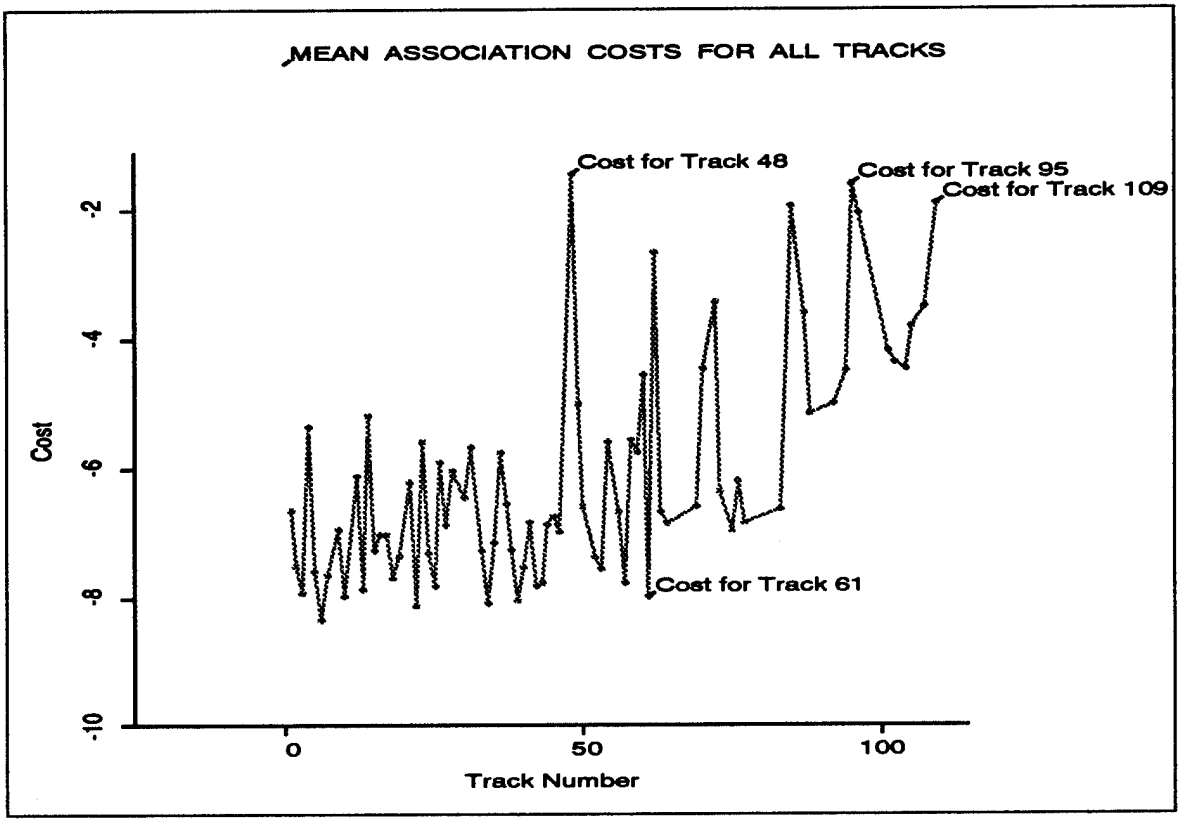


Figure 92

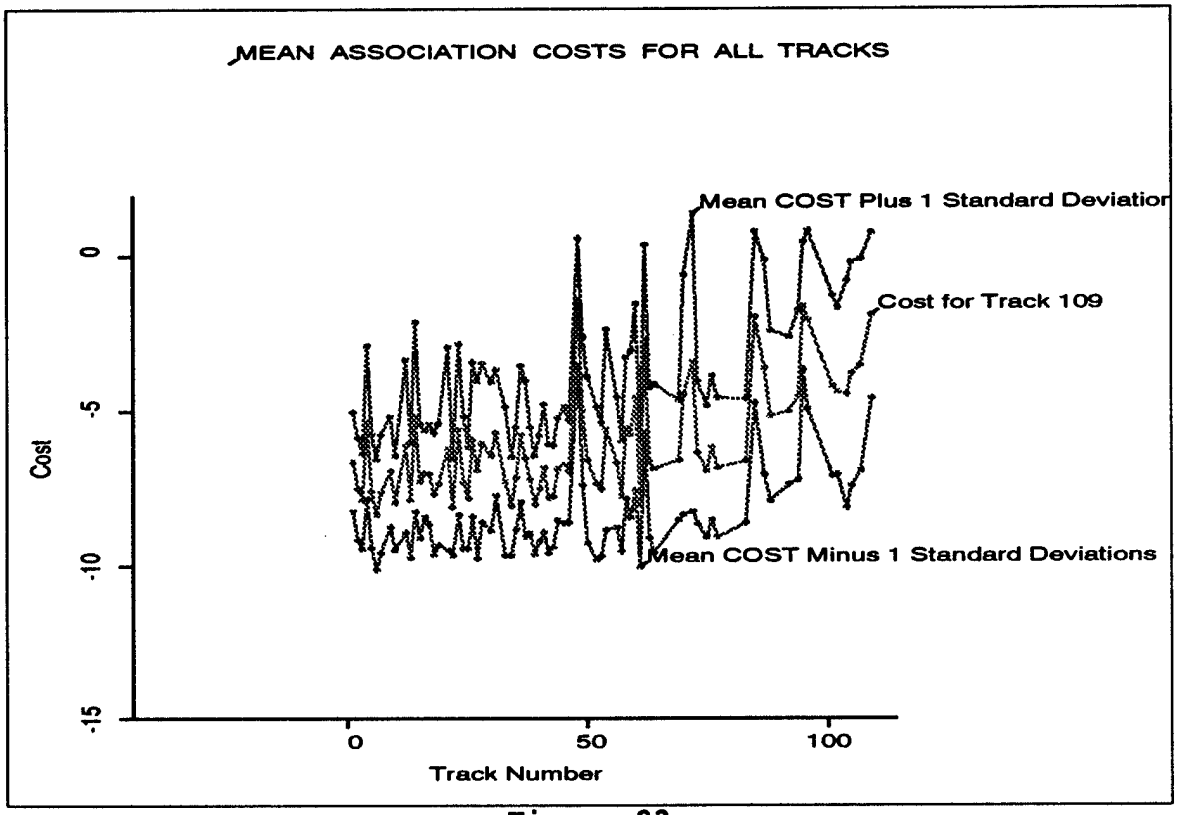


Figure 93

TRACK DATA MENU: *Option 5*

```
Track Data MENU 2:
  0.  PLOT Tracks
  1.  Output Tables by Track Numbers containing Number of Associated Detections and:
      a.  Minimum time and Maximum time
      b.  Range of Track Coordinates
  2.  PLOT One Track
  3.  PLOT One Track and Associated Detections
  4.  PLOT Association Cost
  5.  COMPUTE TABULAR Summary of Innovation (Detections - Track) along with corresponding plot.
  6.  OUTPUT a Table of Target ID vs. Associated Tracks
  7.  PLOT Track Covariances vs. Time
  8.  PLOT Covariance Ellipses for Detections vs. Tracks
  9.  PRINT OUT (by time tick) Selected Data Corresponding to a Particular Track
 10.  PLOT ALL Track Points Corresponding to a Particular Target ID
 11.  PLOT Velocity by Track
 12.  TRANSFER to Scan Data Menu
 13.  QUIT
MENU Choice:  5
```

Figure 94

TRACK DATA MENU *Option 5* allows a User to obtain a Tabular summary of **Innovations (defined as the difference between a Detection Location and a Track Location)** for all calculated Tracks. If One Track is chosen from the menu of **Figure 95** on page A-61, then the Innovation is calculated for each time tick of available data and then displayed along with the mean of these data values. Available from the **ERROR MENU** (**Figure 96** on page A-61) are:

1. **SIGNED Innovations** - A tabular display and plot summarization of the Table.

2. **ABSOLUTE Innovations** - All Innovations are computed via the Absolute Value function and give the User a perspective of how good or bad a Track is without respect to positive or negative sign.

3. **MAGNITUDE of the Innovations** - Since the units for our data are degrees for Latitude and Longitude and kilometers for Altitude, only the Latitude and Longitude values are used to compute the Innovation MAGNITUDES.

4. **East-North-Up Innovations** - All measurements are converted to the **ENU** coordinate system (in terms of kilometers). Each of the three components may be viewed along with the magnitude based on all three components.

If the User chooses to view the Innovations for **ALL TRACKS** from the menu of **Figure 95** on page A-61, then the Tabular summaries will be displayed along with a corresponding plot. Otherwise, only a plot of an individual Track will be shown.

The following pages illustrate the various capabilities available from this *Option*.

TRACK DATA MENU: *Option 5* Continued

```
*********************************************************
MENU for (Detection - Track) Innovation:
     1.  Compute (Detection - Track) Innovation for One Track ONLY
     2.  Compute (Detection - Track) Innovation for ALL TRACKS
MENU Choice:  1
*********************************************************
```

Figure 95

```
*********************************************************
ERROR MENU:
     1.  Compute SIGNED Innovation  (Detection - Calculated Track)
     2.  Compute ABSOLUTE Innovation  ABS(Detection - Calculated Track)
     3.  Compute MAGNITUDE of Innovation  (Lat. & Long. ONLY)
     4.  Compute Innovations in East-North-UP Coordinate System
              and Plot ENU Innovation COMPONENTS and MAGNITUDE
ERROR MENU Choice:  1
*********************************************************
```

Figure 96

The SIGNED Innovation is defined as the difference formed by taking the Associated Detection coordinates and subtracting the Calculated Track coordinates.

```
*******************************************************
Does the User also want to have the Standard Deviations plotted around the MEAN?
    0.  DO NOT PLOT Standard Deviations around the MEAN
    1.  +/- One Standard Deviation    (If Normality Assumed, should include 68.3 per cent of the Data)
    2.  +/- Two Standard Deviations   (If Normality Assumed, should include 95.4 per cent of the Data)
    3.  +/- Three Standard Deviations (If Normality Assumed, should include 99.73 per cent of the Data)
Standard Deviation Choice:  0
*******************************************************
```

Figure 97

```
*********************************************************
INPUT Track Number to be Viewed:  5
*********************************************************
```

Figure 98

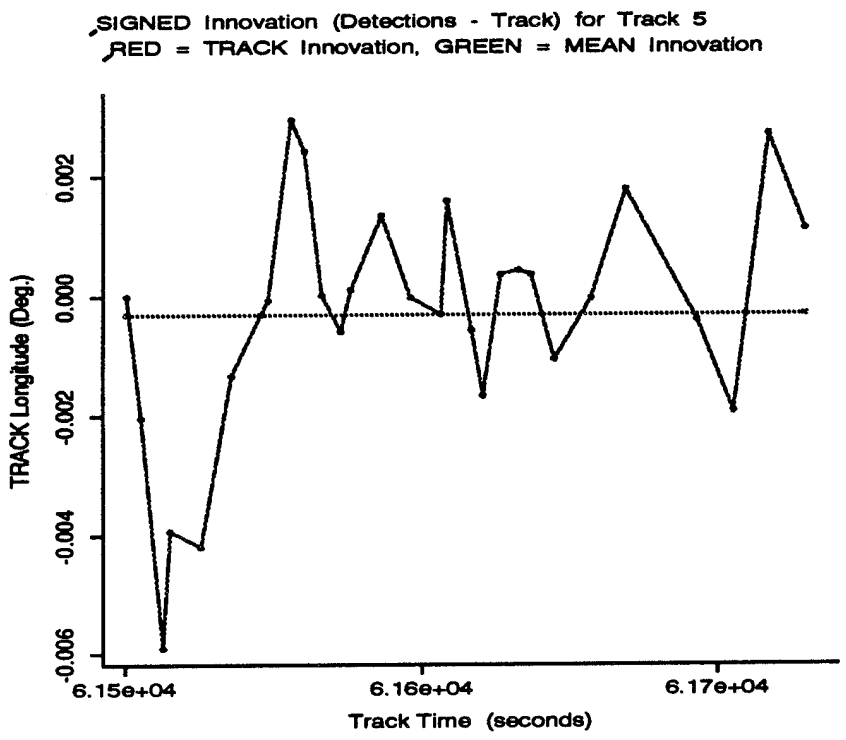


Figure 99
[Track 5 Longitude - SIGNED Innovation]

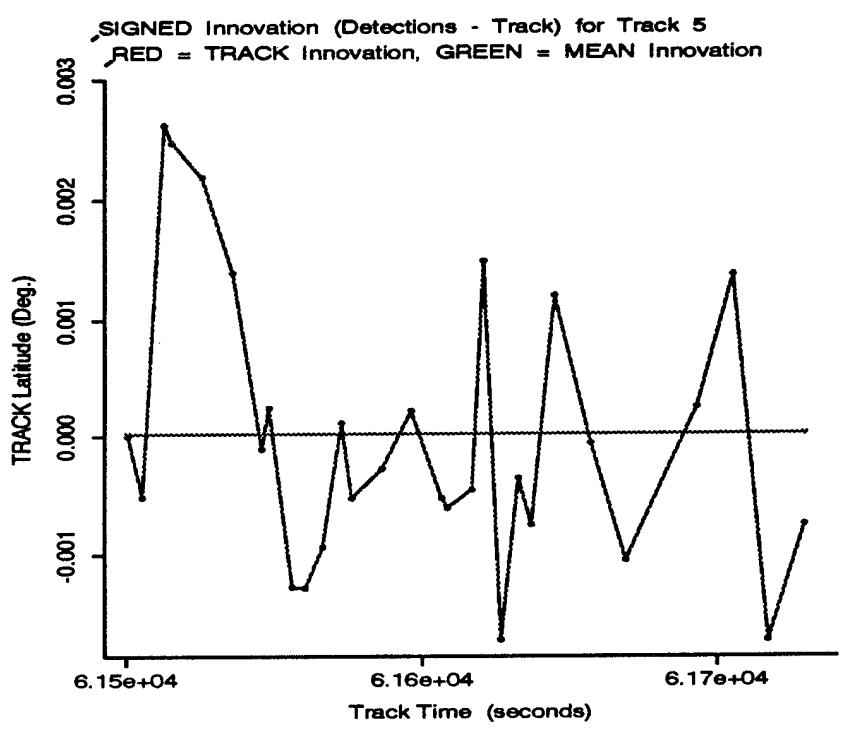


Figure 100
[Track 5 Latitude - SIGNED Innovation]

TRACK DATA MENU: *Option 5* Continued

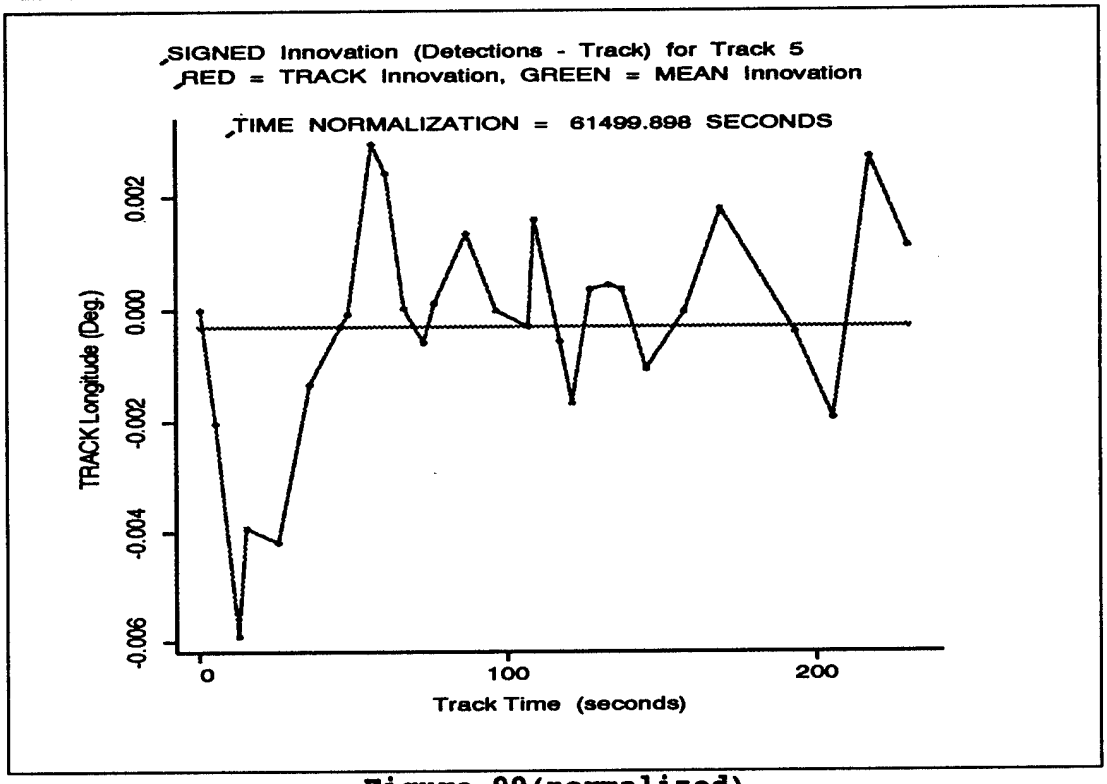


Figure 99(normalized)
[Track 5 Longitude - SIGNED Innovation]

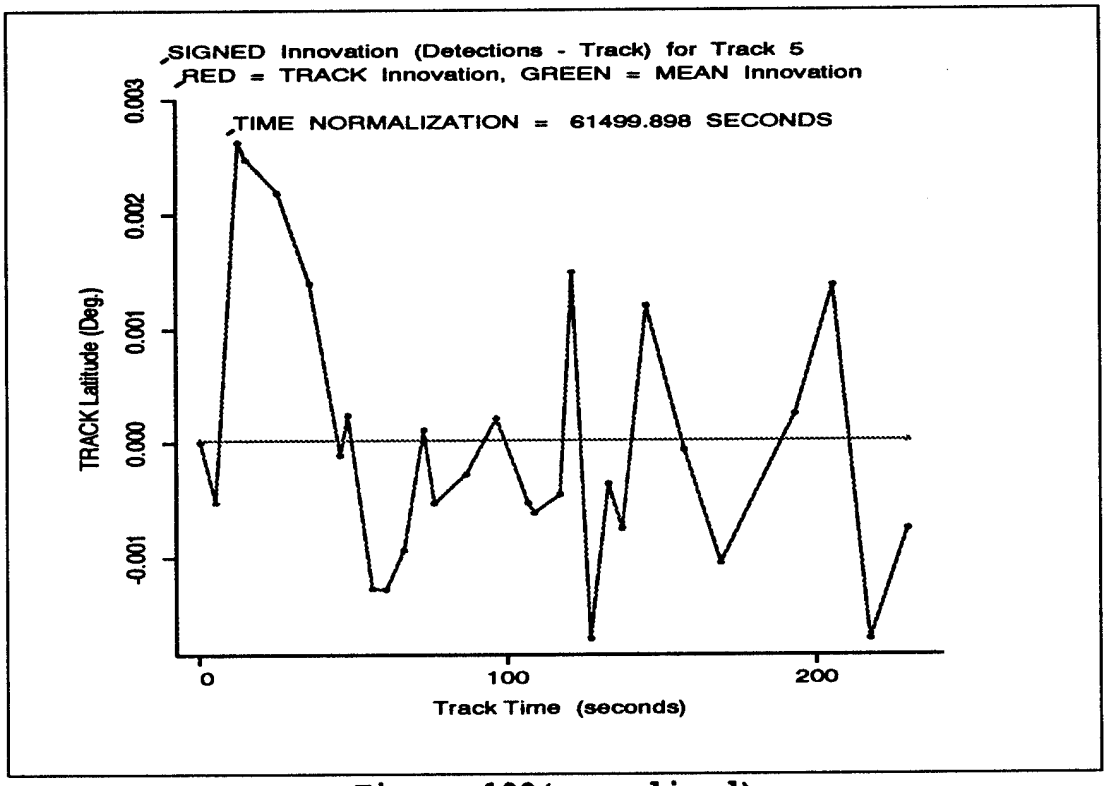


Figure 100(normalized)
[Track 5 Latitude - SIGNED Innovation]

TRACK DATA MENU: *Option 5* Continued

```
*******************************************************
MENU for (Detection - Track) Innovation:
     1.  Compute (Detection - Track) Innovation for One Track ONLY
     2.  Compute (Detection - Track) Innovation for ALL TRACKS
MENU Choice:  1
*******************************************************
```

Figure 95 - Repeated

```
*******************************************************
ERROR MENU:
     1.  Compute SIGNED Innovation  (Detection - Calculated Track)
     2.  Compute ABSOLUTE Innovation  ABS(Detection - Calculated Track)
     3.  Compute MAGNITUDE of Innovation  (Lat. & Long. ONLY)
     4.  Compute Innovations in East-North-UP Coordinate System
           and Plot ENU Innovation COMPONENTS and MAGNITUDE
ERROR MENU Choice:  1
*******************************************************
```

Figure 96 - Repeated

```
*****************************************************
Does the User also want to have the Standard Deviations plotted around the MEAN?
     0.  DO NOT PLOT Standard Deviations around the MEAN
     1.  +/- One Standard Deviation    (If Normality Assumed, should include 68.3 per cent of the Data)
     2.  +/- Two Standard Deviations   (If Normality Assumed, should include 95.4 per cent of the Data)
     3.  +/- Three Standard Deviations (If Normality Assumed, should include 99.73 per cent of the Data)
Standard Deviation Choice:  3
*****************************************************
```

Figure 101

```
*******************************************************
INPUT Track Number to be Viewed:  5
*******************************************************
```

Figure 98 - Repeated

This example is the same as the previous example (**Figures 99 and 100**) except this time lines representing a distance of three Standard Deviations are plotted on each side of the MEAN. Resulting from these inputs are **Figures 102 and 103** on page A-65 and the **NORMALIZED Time Figures 102(normalized) and 103(normalized)** on page A-66.

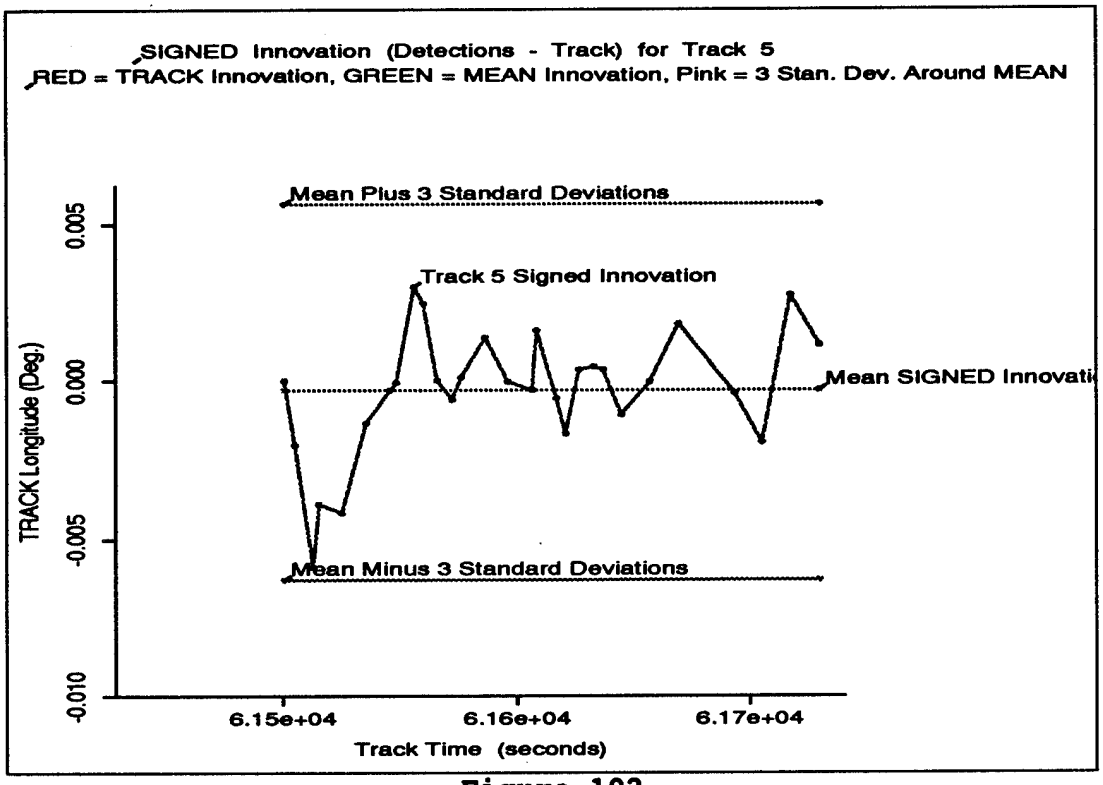


Figure 102
[Track 5 Longitude with Standard Deviation Lines]

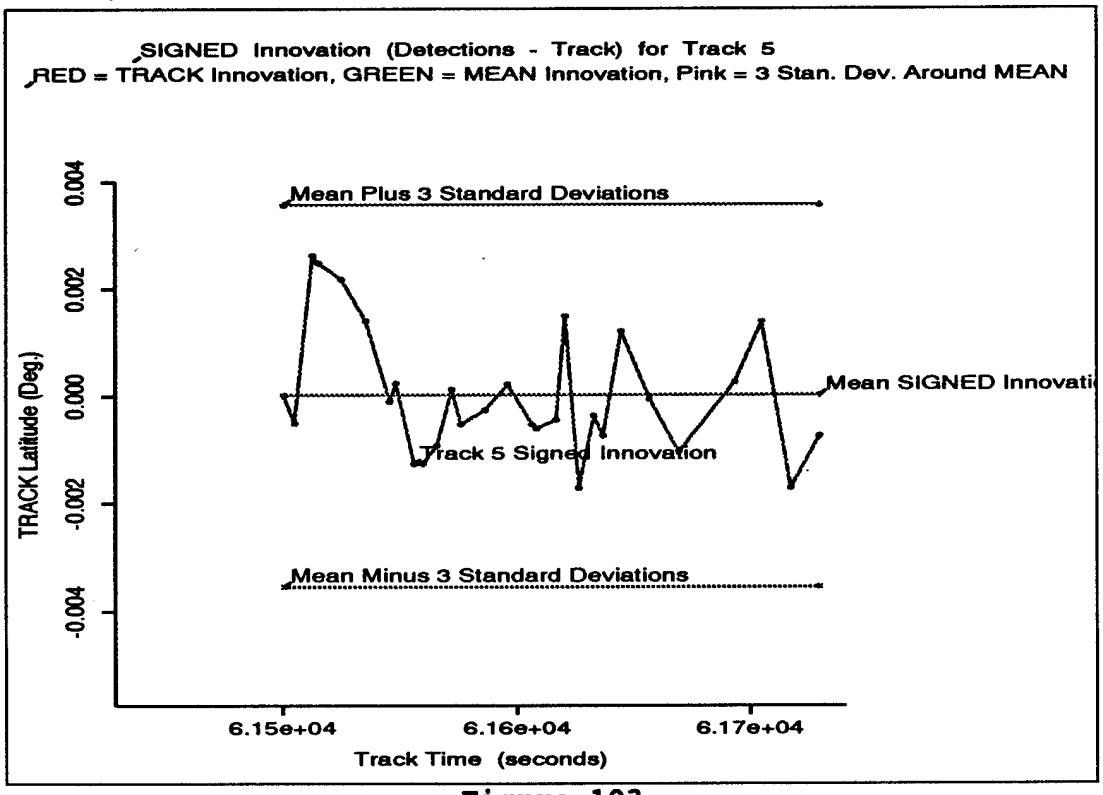


Figure 103
[Track 5 Latitude with Standard Deviation Lines]

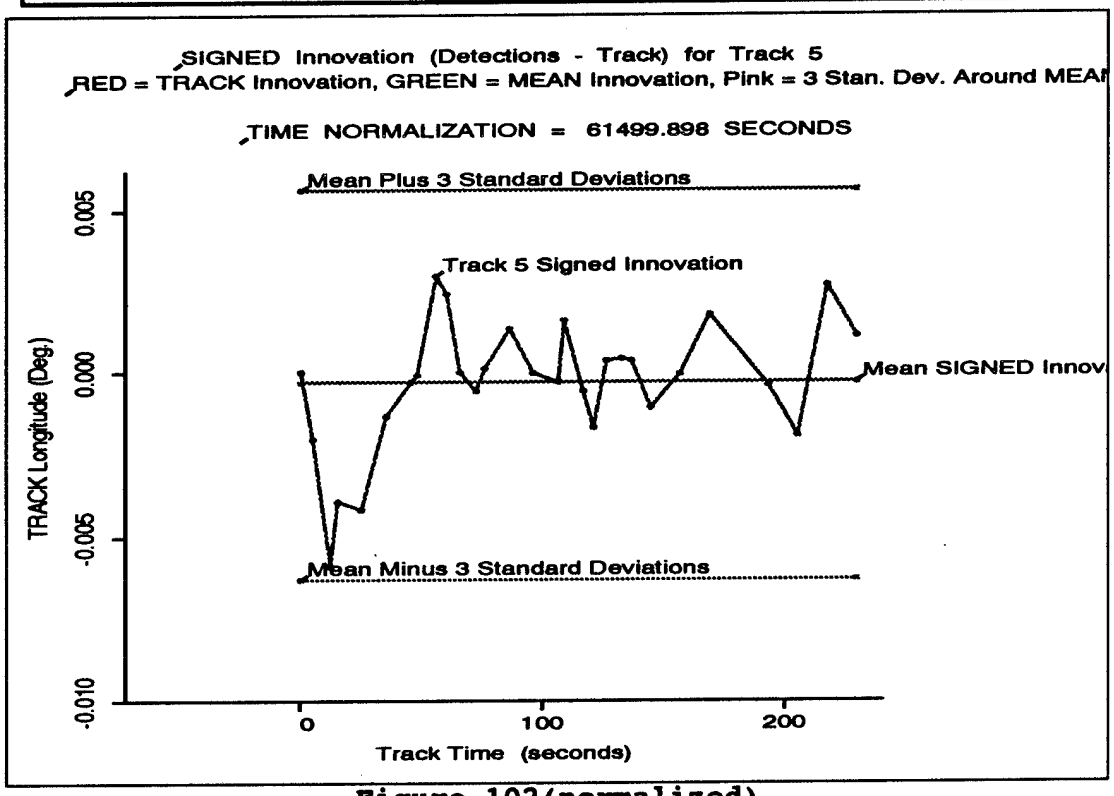


Figure 102(normalized)
[Track 5 Longitude with Standard Deviation Lines]

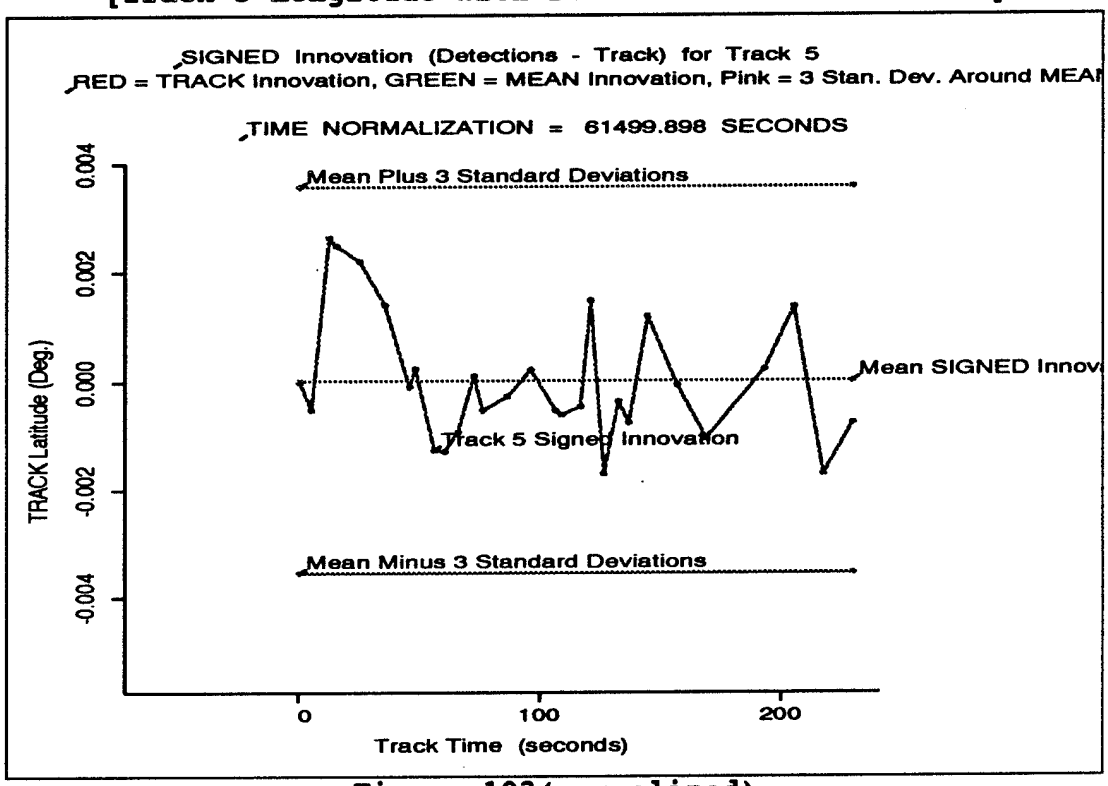


Figure 103(normalized)
[Track 5 Latitude with Standard Deviation Lines]

TRACK DATA MENU: *Option 5* Continued

```
*********************************************************
MENU for (Detection - Track) Innovation:
     1.  Compute (Detection - Track) Innovation for One Track ONLY
     2.  Compute (Detection - Track) Innovation for ALL TRACKS
MENU Choice:  1
*********************************************************
```

Figure 95 - Repeated

```
*********************************************************
ERROR MENU:
     1.  Compute SIGNED Innovation  (Detection - Calculated Track)
     2.  Compute ABSOLUTE Innovation  ABS(Detection - Calculated Track)
     3.  Compute MAGNITUDE of Innovation  (Lat. & Long. ONLY)
     4.  Compute Innovations in East-North-UP Coordinate System
           and Plot ENU Innovation COMPONENTS and MAGNITUDE
ERROR MENU Choice:  2
*********************************************************
```

Figure 104

The ABSOLUTE Innovation is defined as the ABSOLUTE VALUE OF the difference formed by taking the Associated Detection coordinates and subtracting the Calculated Track coordinates.

```
*****************************************************
Does the User also want to have the Standard Deviations plotted around the MEAN?
    0.  DO NOT PLOT Standard Deviations around the MEAN
    1.  +/- One Standard Deviation    (If Normality Assumed, should include 68.3 per cent of the Data)
    2.  +/- Two Standard Deviations   (If Normality Assumed, should include 95.4 per cent of the Data)
    3.  +/- Three Standard Deviations (If Normality Assumed, should include 99.73 per cent of the Data)
Standard Deviation Choice:  0
*****************************************************
```

Figure 97 - Repeated

```
*********************************************************
INPUT Track Number to be Viewed:  5
*********************************************************
```

Figure 98 - Repeated

This example is the same as the first *Option 5* example (**Figures 99 and 100**) except this time the **ABSOLUTE Innovation** is plotted rather than the SIGNED Innovation. Plots for this case are on the next page (**Figures 105 and 106** un-normalized and normalized on the next two pages).

TRACK DATA MENU: *Option 5* Continued

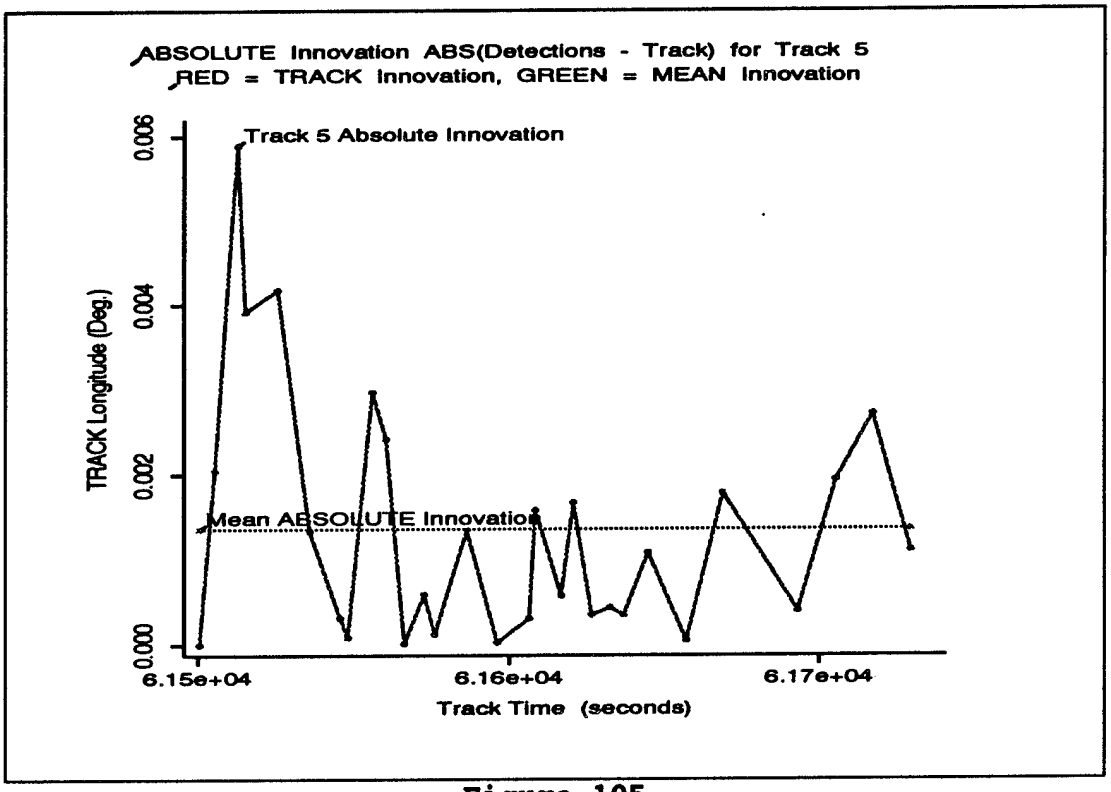


Figure 105
[Track 5 Longitude - ABSOLUTE Innovation]

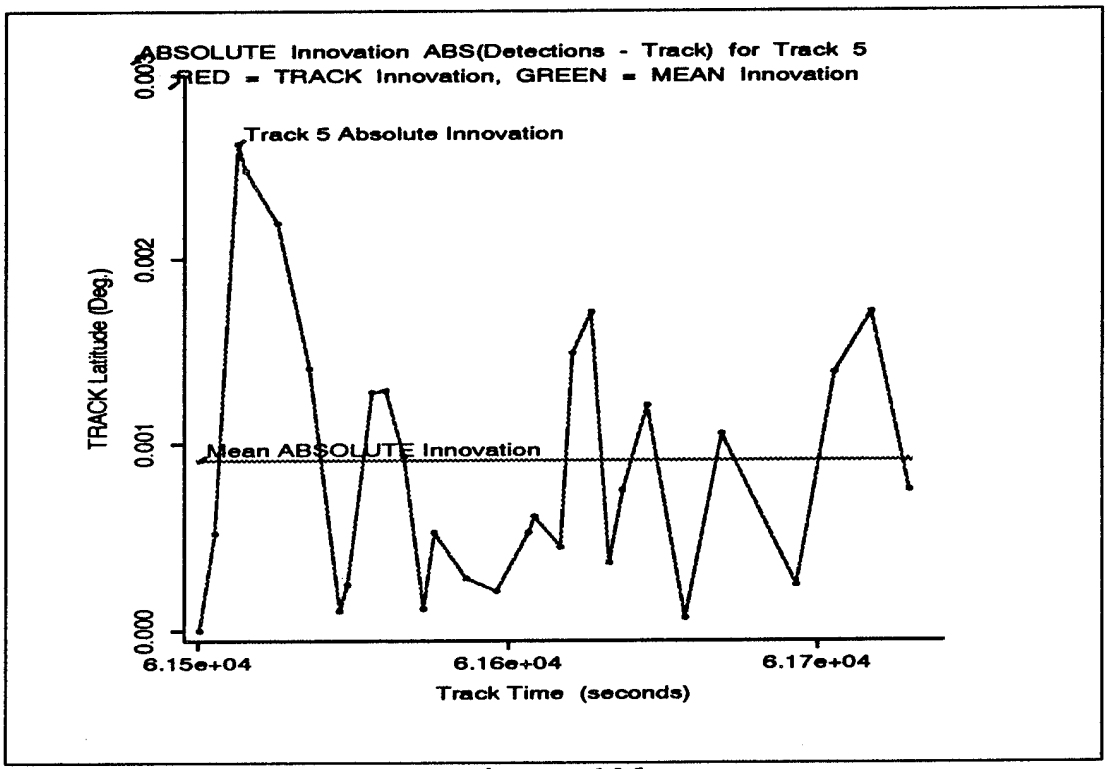


Figure 106
[Track 5 Latitude - ABSOLUTE Innovation]

TRACK DATA MENU: *Option 5* Continued

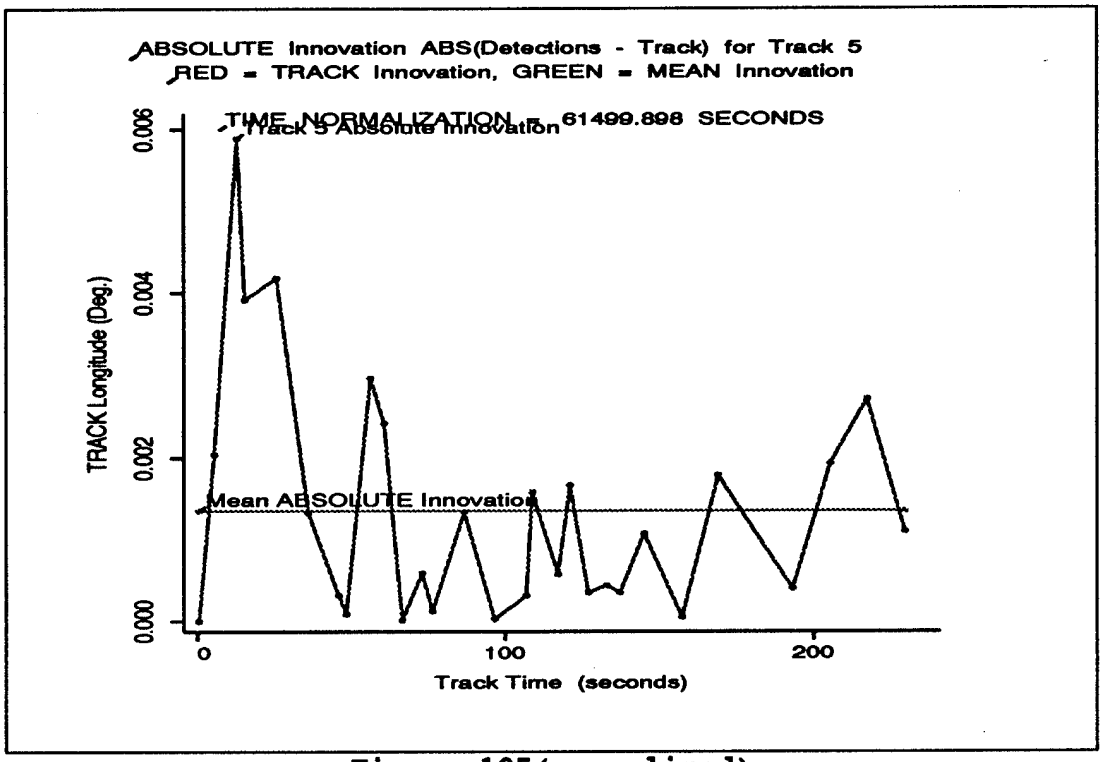


Figure 105(normalized)
[Track 5 Longitude - ABSOLUTE Innovation]

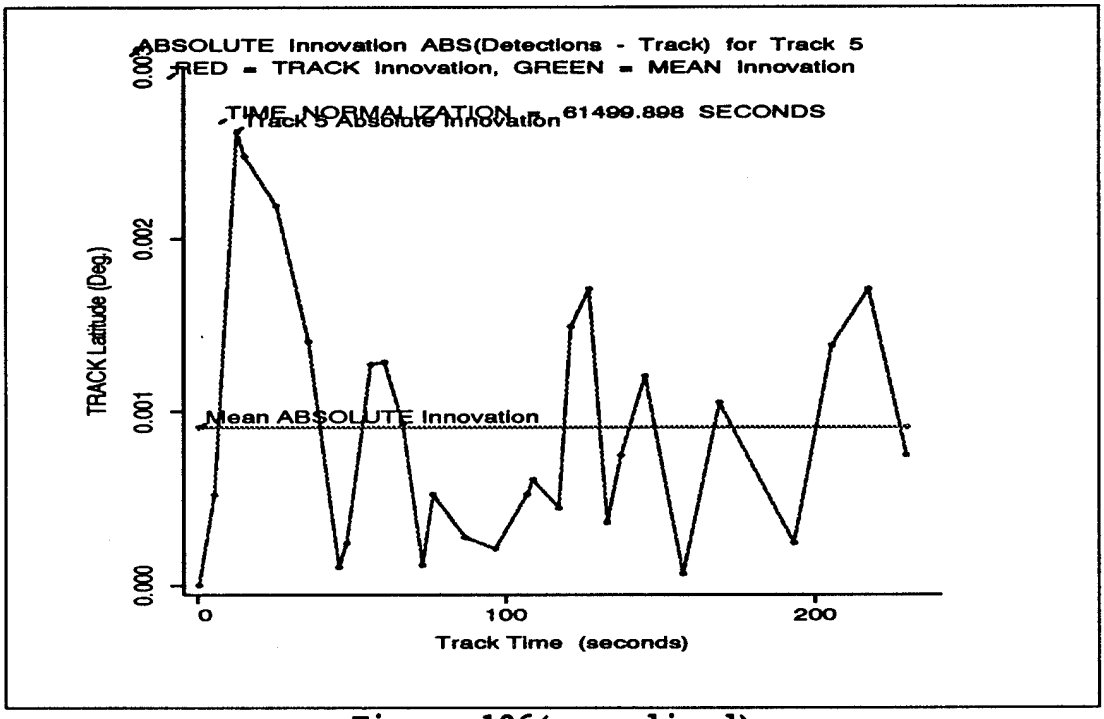


Figure 106(normalized)
[Track 5 Latitude - ABSOLUTE Innovation]

TRACK DATA MENU: *Option 5* Continued

```
**********************************************************
MENU for (Detection - Track) Innovation:
     1.  Compute (Detection - Track) Innovation for One Track ONLY
     2.  Compute (Detection - Track) Innovation for ALL TRACKS
MENU Choice:  1
**********************************************************
```

Figure 95 - Repeated

```
**********************************************************
ERROR MENU:
     1.  Compute SIGNED Innovation  (Detection - Calculated Track)
     2.  Compute ABSOLUTE Innovation  ABS(Detection - Calculated Track)
     3.  Compute MAGNITUDE of Innovation  (Lat. & Long. ONLY)
     4.  Compute Innovations in East-North-UP Coordinate System
              and Plot ENU Innovation COMPONENTS and MAGNITUDE
ERROR MENU Choice:  3
**********************************************************
```

Figure 107

In this case, the MAGNITUDE of the Innovation is defined as the Square Root of the Sum of the Squares of the differences formed by taking the Associated Detection coordinates and subtracting the Calculated Track coordinates (Latitude and Longitude only).

```
**********************************************************
INPUT Track Number to be Viewed:  5
**********************************************************
```

Figure 98 - Repeated

For *Option 5* from the **Track Data Menu**, the User has in this example chosen to see the Innovations for one Track only (**Figure 95**) and has also chosen to see the **MAGNITUDE of the Innovation.** Because of unit differences, this MAGNITUDE is based solely on the Latitude and Longitude values, yielding a MAGNITUDE in degrees (**Figure 108** on page A-71 or **Figure 108(normalized)** on page A-72).

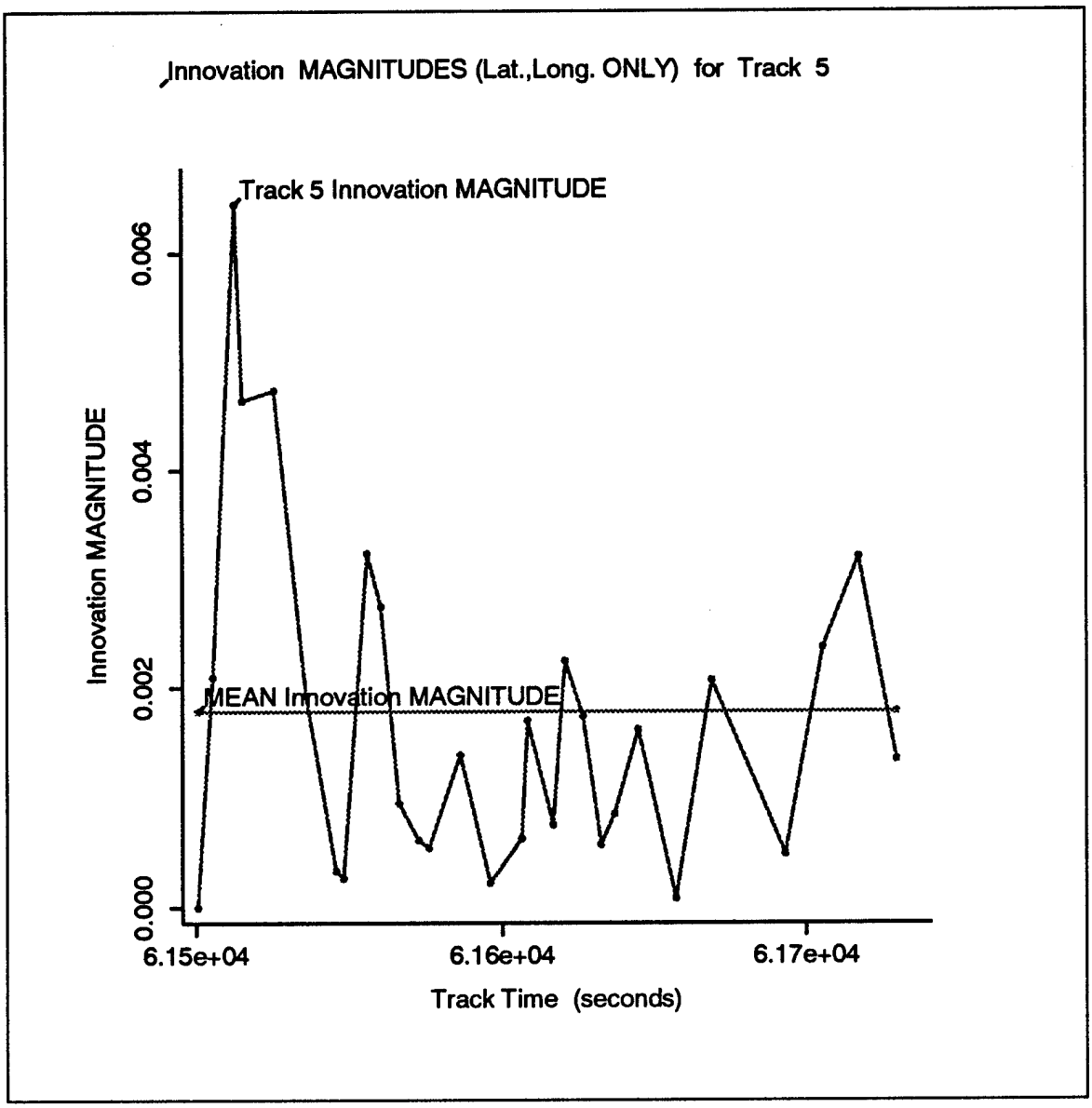


Figure 108
[Track 5 Innovation MAGNITUDE]
(Latitude, Longitude ONLY Used in Computation)

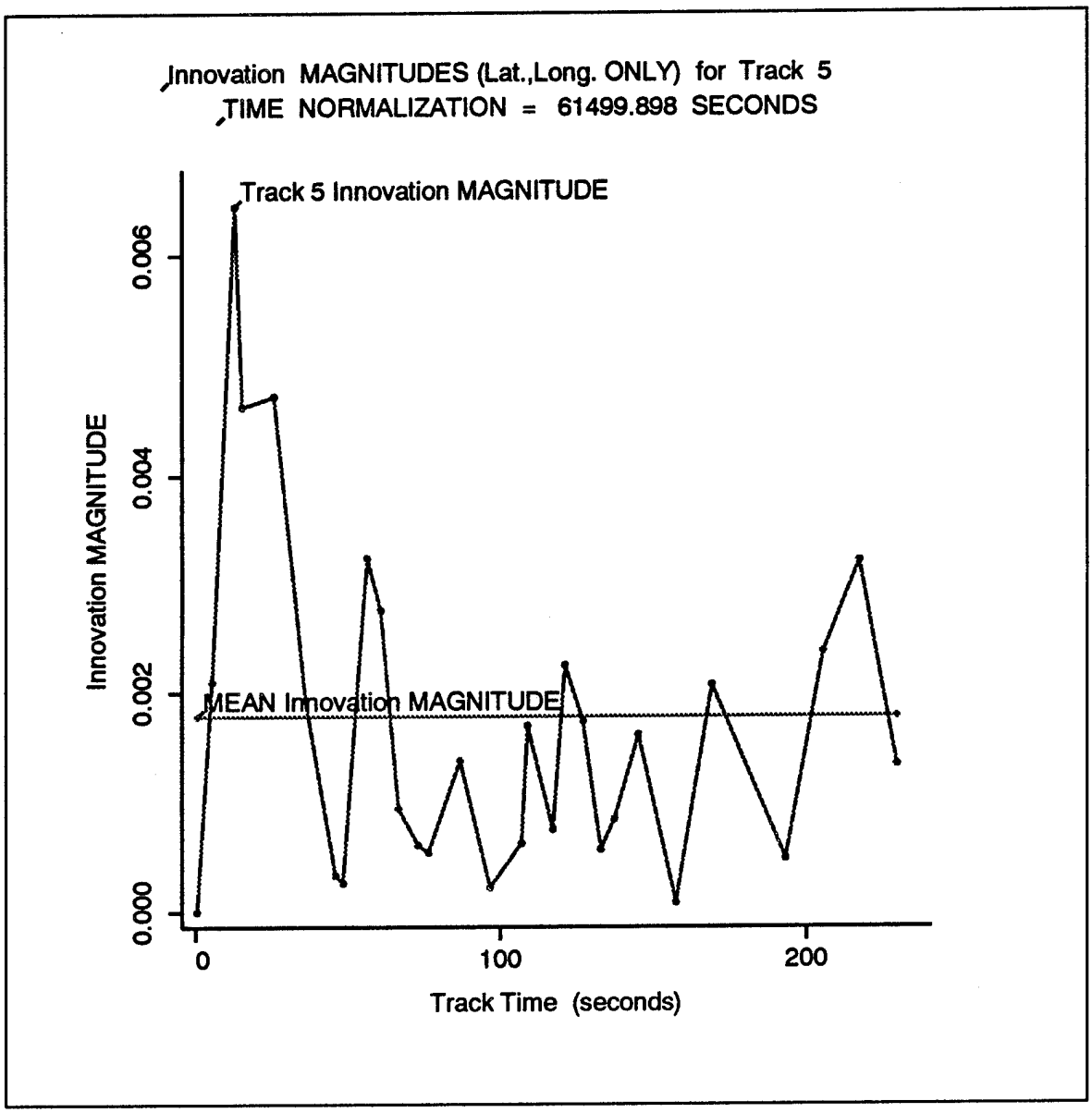


Figure 108(normalized)
[Track 5 Innovation MAGNITUDE]
(Latitude, Longitude ONLY Used in Computation)

TRACK DATA MENU: *Option 5* Continued

```
**********************************************************
MENU for (Detection - Track) Innovation:
     1.  Compute (Detection - Track) Innovation for One Track ONLY
     2.  Compute (Detection - Track) Innovation for ALL TRACKS
MENU Choice:  1
**********************************************************
```

Figure 95 - Repeated

```
*****************************************************
ERROR MENU:
     1.  Compute SIGNED Innovation  (Detection - Calculated Track)
     2.  Compute ABSOLUTE Innovation  ABS(Detection - Calculated Track)
     3.  Compute MAGNITUDE of Innovation  (Lat. & Long. ONLY)
     4.  Compute Innovations in East-North-UP Coordinate System
              and Plot ENU Innovation COMPONENTS and MAGNITUDE
ERROR MENU Choice:  4
*****************************************************
```

Figure 109

```
*********************************************************
ENU Component ERROR MENU:
     1.  Compute SIGNED  ENU  Innovation
     2.  Compute ABSOLUTE  ENU  Innovation
ENU Component ERROR MENU Choice:  1
*********************************************************
```

Figure 110

```
*********************************************************
INPUT Track Number to be Viewed:  5
*********************************************************
```

Figure 98 - Repeated

In order to observe the Innovation MAGNITUDE using all three components of Input and Computed Data (Latitude, Longitude, and Altitude), the Track Point and Associated Detection Point are converted to the **East-North-Up Coordinate System** in which all units are in kilometers (with the Track Point as origin of the coordinate system). The three components of the Innovation are then available for display along with a MAGNITUDE based on the square root of the sum of the squares of the differences of the three components. In addition, the three **ENU** components are available as "signed" values (the signs of the Associated Detection Point with respect to the Track Point) or as unsigned (absolute) values. The four plots on the next two pages illustrate these capabilities, with the SIGNED ENU Innovations using the UN-NORMALIZED times.

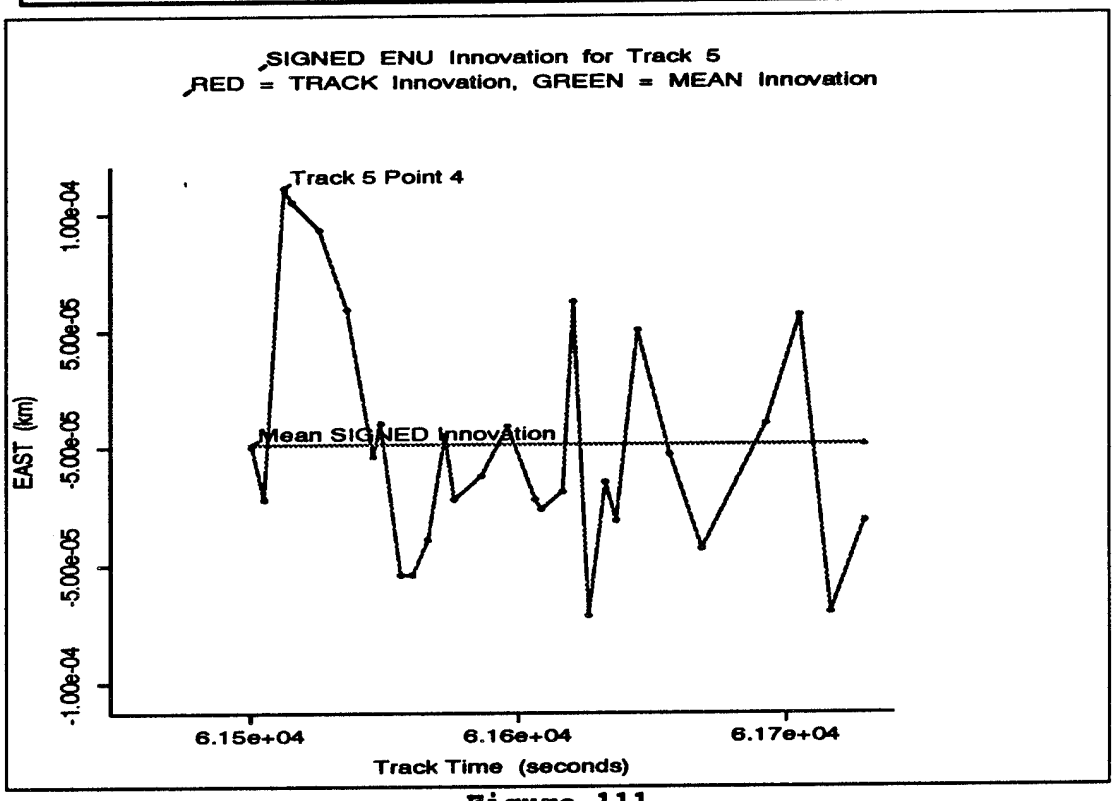


Figure 111
[Track 5 ENU "Signed" Innovation East Component]

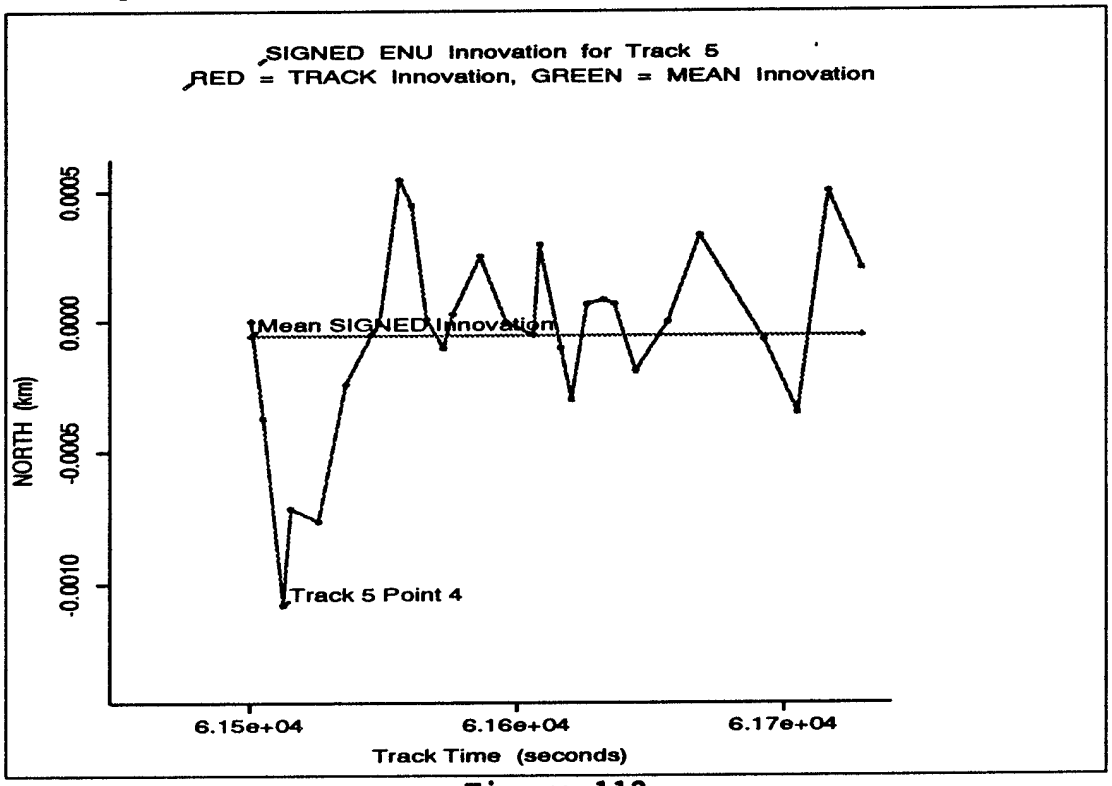


Figure 112
[Track 5 ENU "Signed" Innovation North Component]

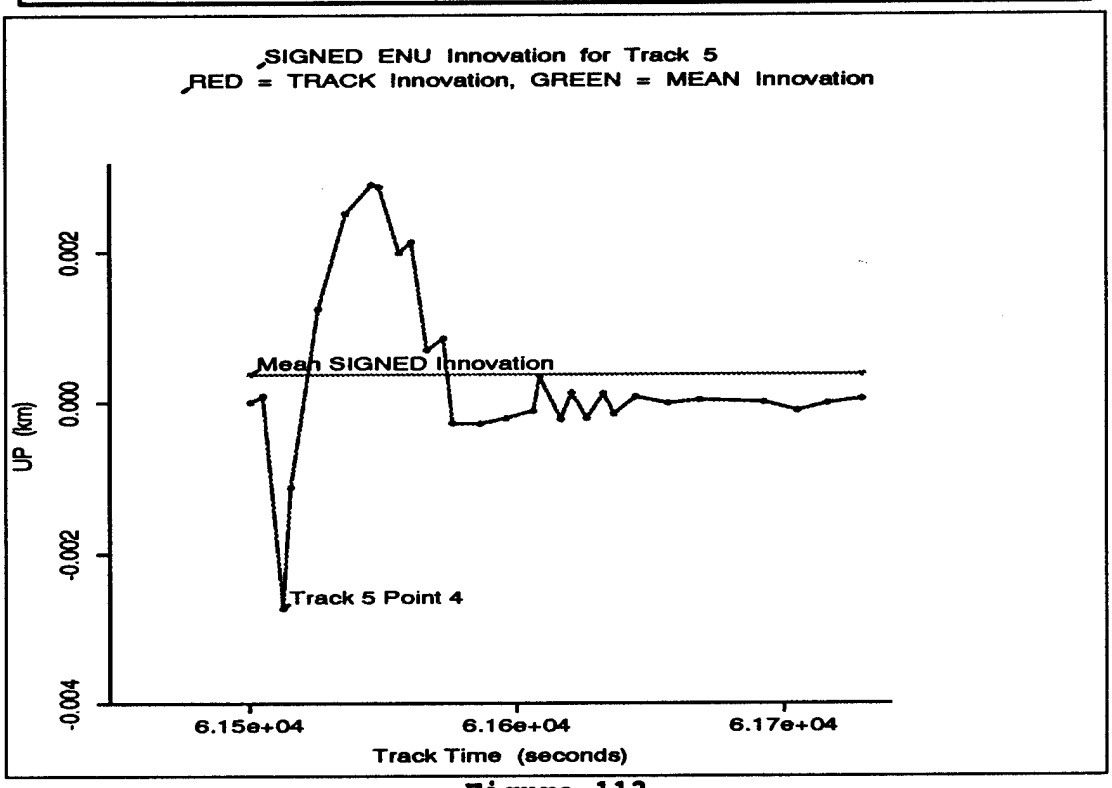


Figure 113
[Track 5 ENU "Signed" Innovation Up Component]

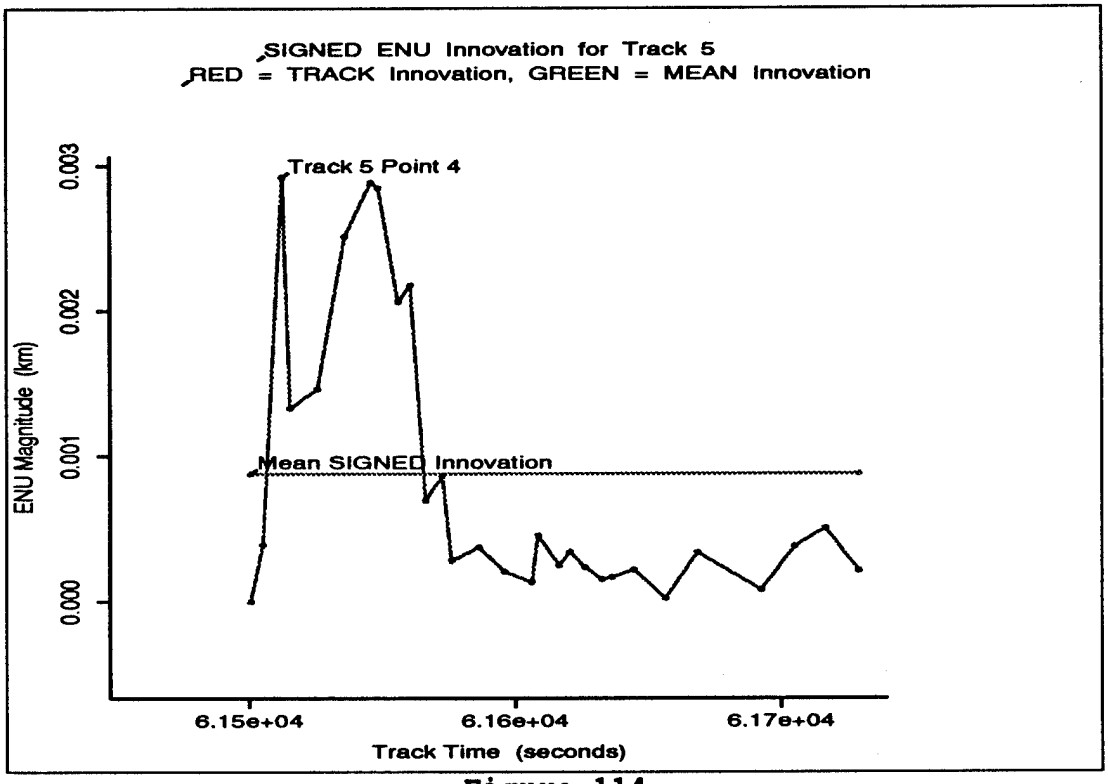


Figure 114
[Track 5 ENU Magnitude]

TRACK DATA MENU: *Option 5* Continued

```
*******************************************************
MENU for (Detection - Track) Innovation:
     1.  Compute (Detection - Track) Innovation for One Track ONLY
     2.  Compute (Detection - Track) Innovation for ALL TRACKS
MENU Choice:  1
*******************************************************
```

Figure 95 - Repeated

```
*******************************************************
ERROR MENU:
     1.  Compute SIGNED Innovation  (Detection - Calculated Track)
     2.  Compute ABSOLUTE Innovation  ABS(Detection - Calculated Track)
     3.  Compute MAGNITUDE of Innovation  (Lat. & Long. ONLY)
     4.  Compute Innovations in East-North-UP Coordinate System
              and Plot ENU Innovation COMPONENTS and MAGNITUDE
ERROR MENU Choice:  4
*******************************************************
```

Figure 109 - Repeated

```
*****************************************************
ENU Component ERROR MENU:
     1.  Compute SIGNED  ENU  Innovation
     2.  Compute ABSOLUTE  ENU  Innovation
ENU Component ERROR MENU Choice:  2
*****************************************************
```

Figure 115

```
*****************************************************
INPUT Track Number to be Viewed:  5
*****************************************************
```

Figure 98 - Repeated

This case continues to illustrate Track Data MENU Option 2 and is the same as the previous example except that *Choice 2* is made from the **ENU Component ERROR MENU (Figure 115).** NORMALIZED and UN-NORMALIZED **Figures 116, 117, 118, and 119** on the next four pages result from these *choices.*

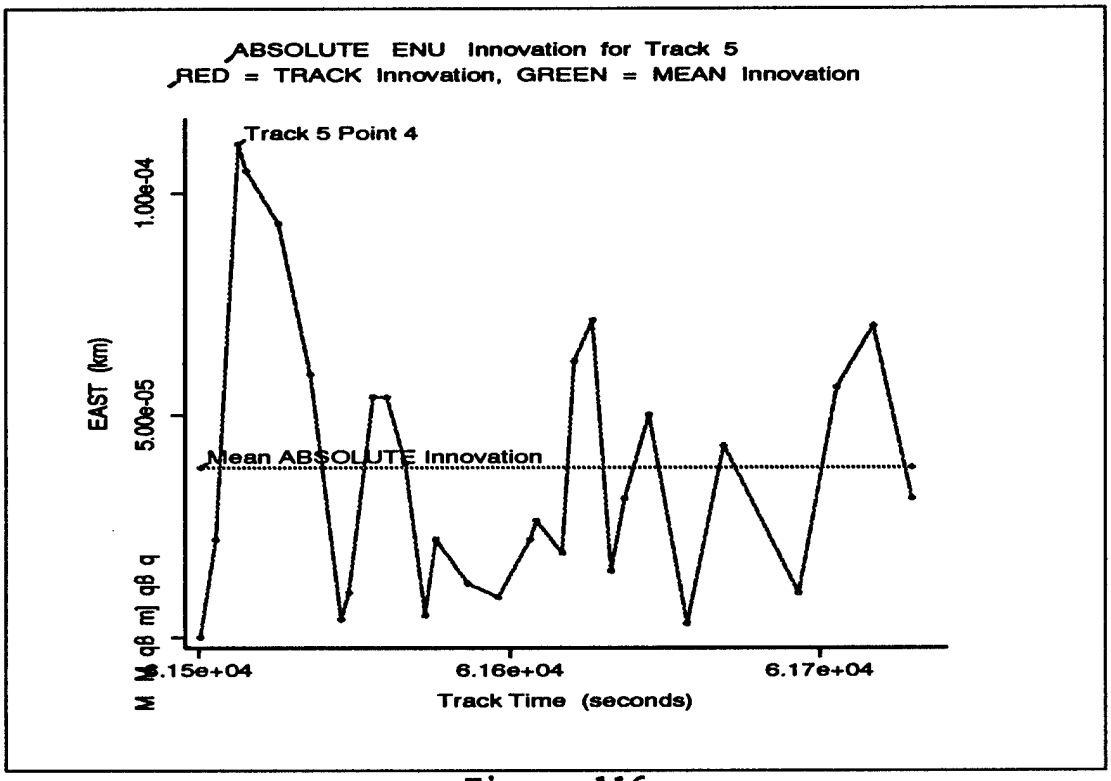


Figure 116
[Track 5 ENU "Absolute" Innovation East Component]

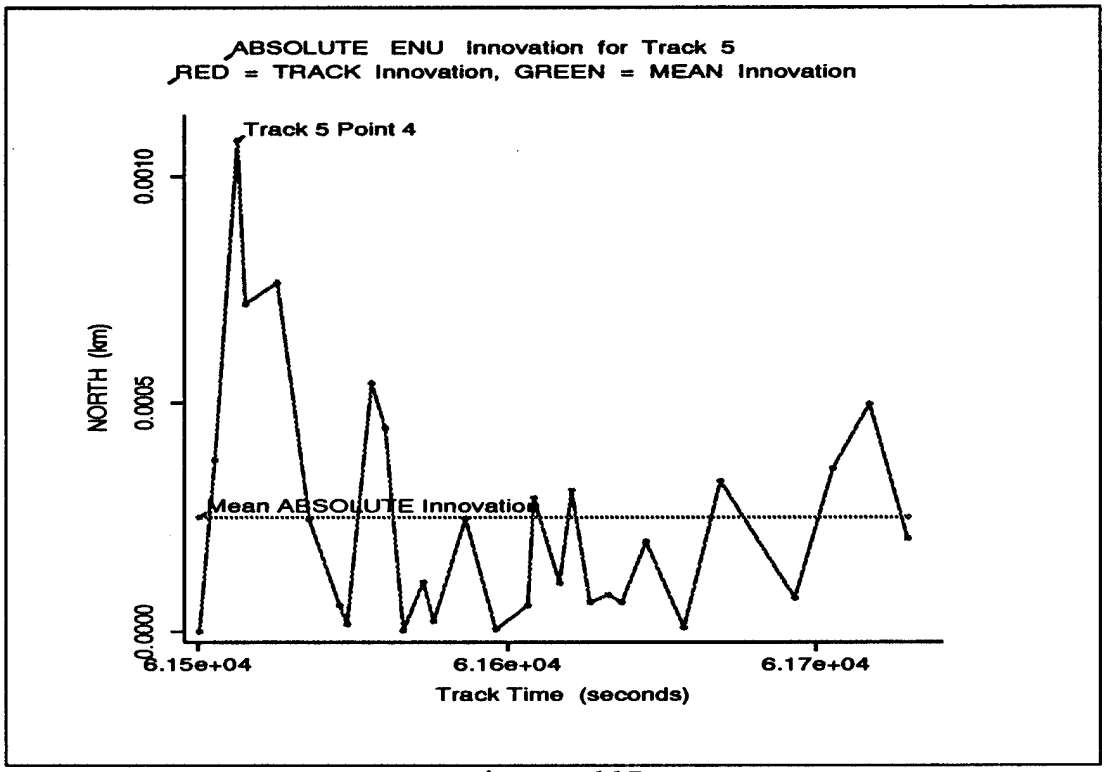


Figure 117
[Track 5 ENU "Absolute" Innovation North Component]

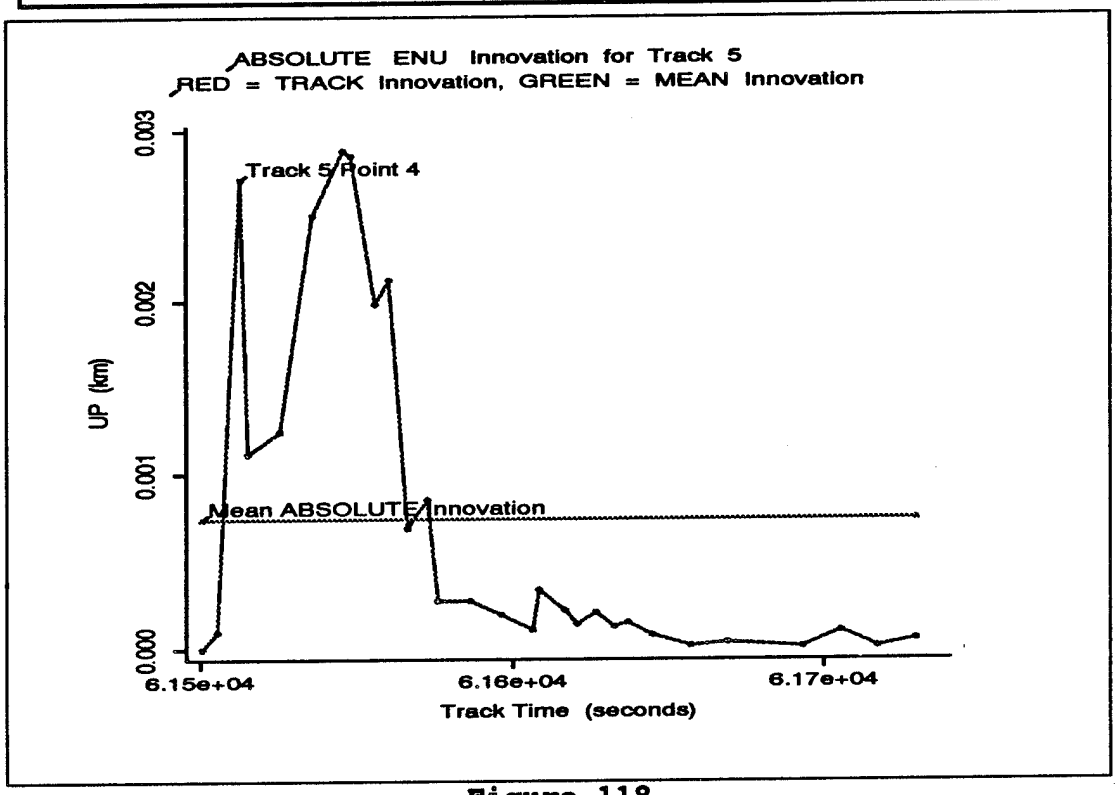


Figure 118
[Track 5 ENU "Absolute" Innovation Up Component]

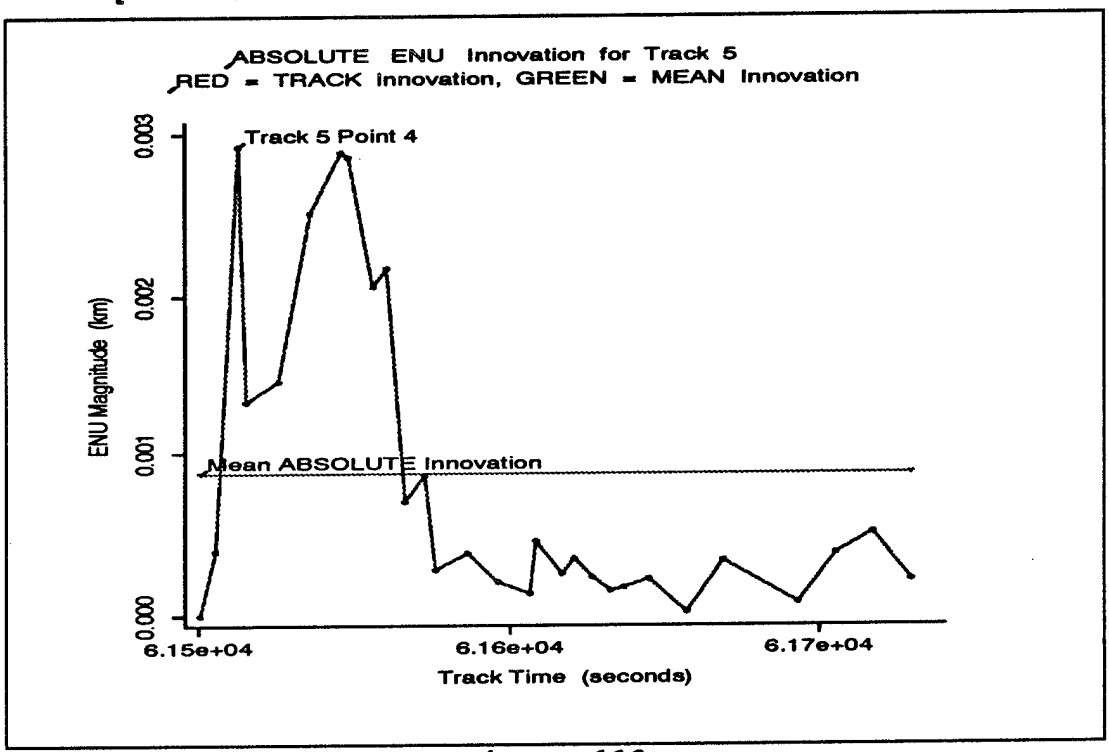


Figure 119
[Track 5 ENU Magnitude]

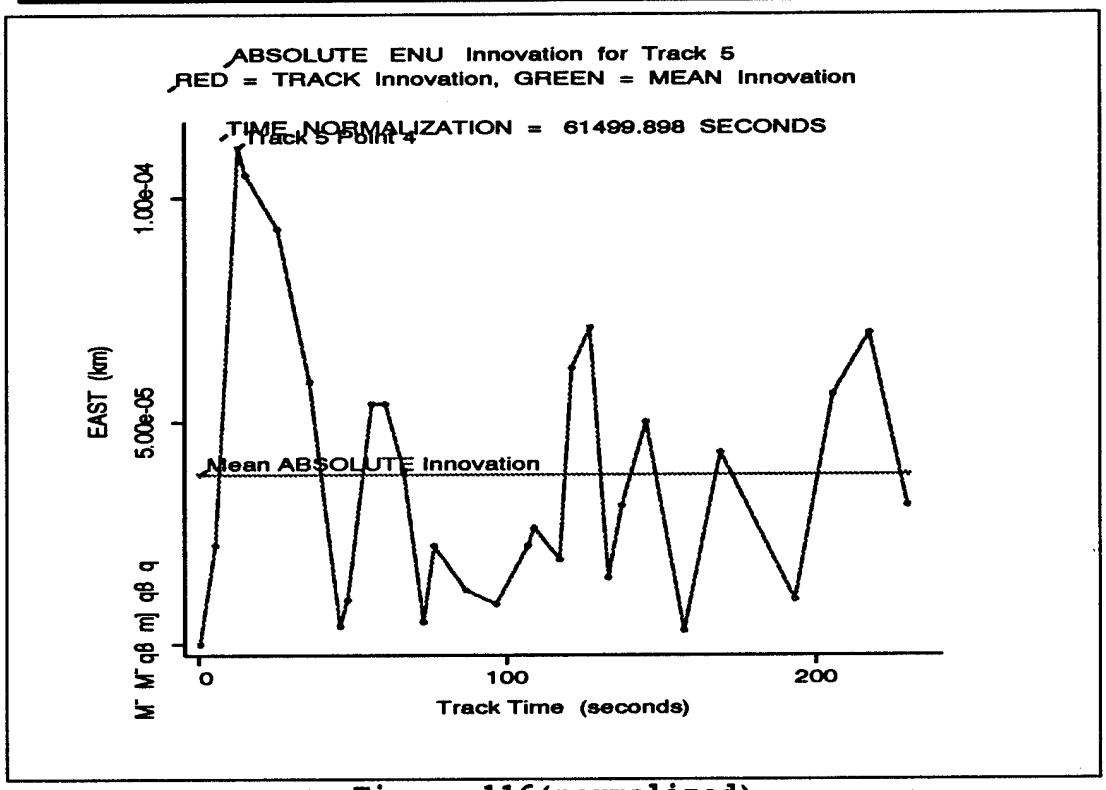


Figure 116(normalized)
[Track 5 ENU "Absolute" Innovation East Component]

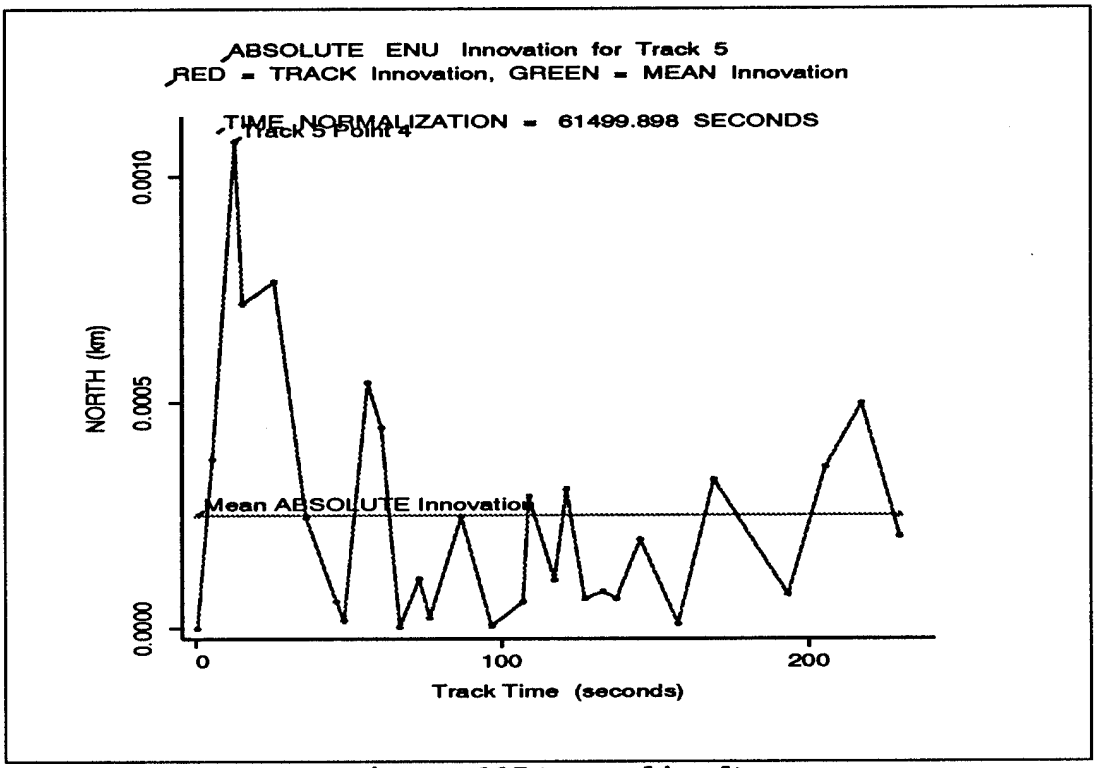


Figure 117(normalized)
[Track 5 ENU "Absolute" Innovation North Component]

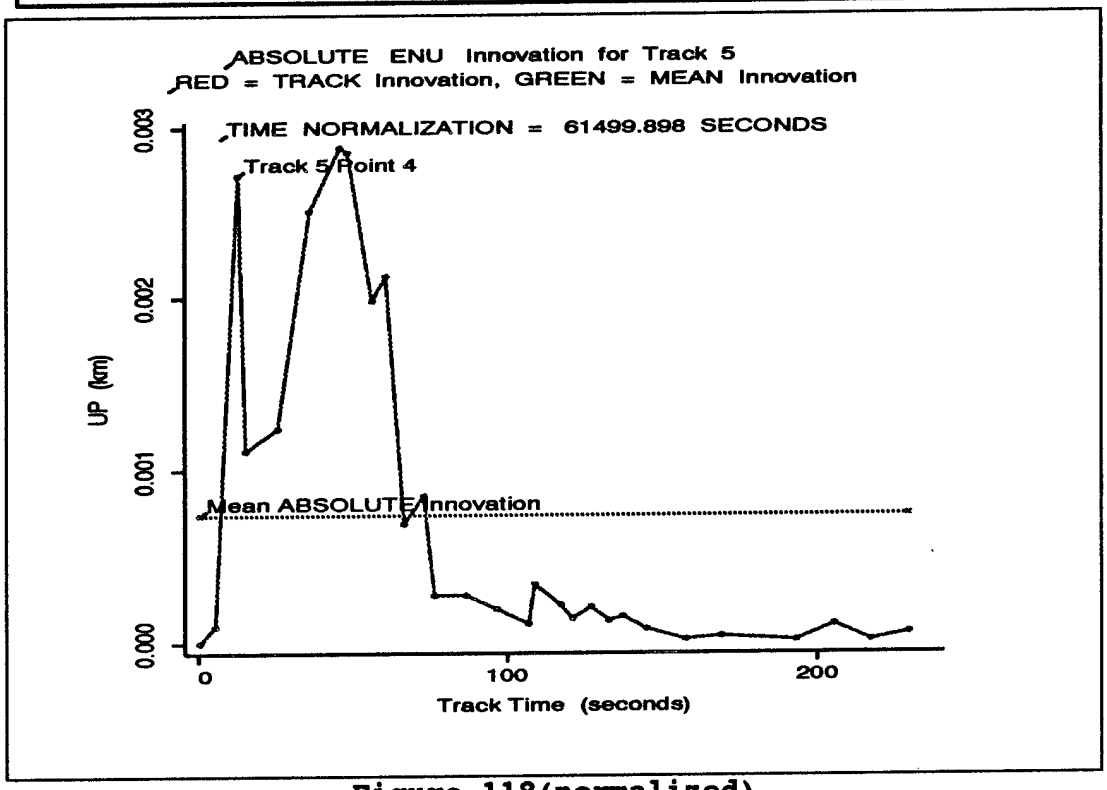


Figure 118(normalized)
[Track 5 ENU "Absolute" Innovation Up Component]

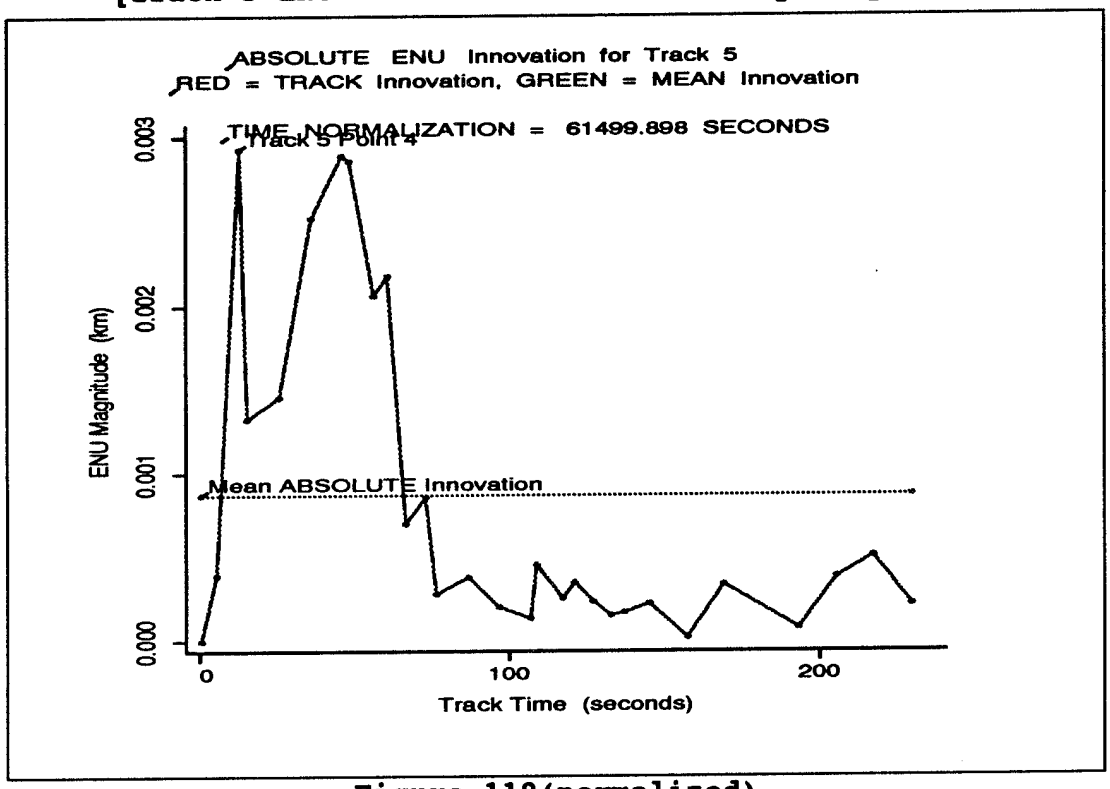


Figure 119(normalized)
[Track 5 ENU Magnitude]

TRACK DATA MENU: *Option 5* Continued

```
**********************************************************
MENU for (Detection - Track) Innovation:
     1.  Compute (Detection - Track) Innovation for One Track ONLY
     2.  Compute (Detection - Track) Innovation for ALL TRACKS
MENU Choice:  2
**********************************************************
```

Figure 120

```
**********************************************************
ERROR MENU:
     1.  Compute SIGNED Innovation  (Detection - Calculated Track)
     2.  Compute ABSOLUTE Innovation  ABS(Detection - Calculated Track)
     3.  Compute MAGNITUDE of Innovation  (Lat. & Long. ONLY)
     4.  Compute Innovations in East-North-UP Coordinate System
              and Plot ENU Innovation COMPONENTS and MAGNITUDE
ERROR MENU Choice:  1
**********************************************************
```

Figure 96 - Repeated

```
*****************************************************
Does the User also want to have the Standard Deviations plotted around the MEAN?
    0.  DO NOT PLOT Standard Deviations around the MEAN
    1.  +/- One Standard Deviation   (If Normality Assumed, should include 68.3 per cent of the Data)
    2.  +/- Two Standard Deviations  (If Normality Assumed, should include 95.4 per cent of the Data)
    3.  +/- Three Standard Deviations (If Normality Assumed, should include 99.73 per cent of the Data)
Standard Deviation Choice:  0
*****************************************************
```

Figure 97 - Repeated

This example is to illustrate *Option 2* from the menu of **Figure 120.** This *Option* will examine Innovations for **ALL** Tracks generated by a particular run of a given Algorithm The **SIGNED Innovation** choice is made (**Figure 96 - Repeated**) and the **0. DO NOT PLOT Standard Deviations** *Option* is chosen (**Figure 97 - Repeated**).

Since ALL TRACKS is chosen, the first items to be displayed are the TABLES of **Figures 122, 123, and 124** on the next three pages. The first two TABLES list each TRACK which has more than one Associated Detection and then list the **MEAN Innovation** (either **SIGNED** or **ABSOLUTE**) for each dimension and the Standard Deviation for each of these MEAN Innovations. The TABLE of **Figure 124** outputs the Innovation MAGNITUDE based on Latitude and Longitude only.

After each Table is displayed, the usual **HARD COPY** question is posed (**Figure 121 below**) and then the plots of **Figures 125 and 126** on page A-85 are displayed.

```
*****************************************************
Do you want to have a HARD COPY of the above TABLE?
     1)  YES
     2)  NO  [or push <Enter> TWO TIMES]
1
```

Figure 121

TRACK DATA MENU: *Option 5* **Continued**

Track Number	Number of Associated Detects	Mean SIGNED Innovation Long.	Lat.	Alt.	Standard Deviations Long.	Lat.	Alt.
1	35	-9.395e-05	-0.0008678	-0.001024	0.002406	0.002478	0.006483
2	40	-0.0003832	6.809e-05	0.0001769	0.002897	0.001387	0.0007929
3	43	-0.0002115	0.0005627	7.056e-05	0.00135	0.001714	0.001038
4	15	-3.815e-05	2.34e-05	0.0003227	0.0002365	0.0001782	0.003489
5	29	-0.0003165	2.315e-05	0.000366	0.001987	0.001185	0.001183
6	43	-0.0005873	0.000442	-3.269e-05	0.002117	0.001069	0.0004218
7	40	-9.975e-05	2.613e-05	7.195e-05	0.00218	0.001485	0.0006303
9	32	0.0001447	-9.274e-05	0.0001907	0.00156	0.001606	0.005058
10	45	0.0002523	-0.0001342	0.0001163	0.001392	0.00164	0.004035
12	17	-8.572e-05	4.757e-05	-0.0002022	0.0002704	0.0002549	0.001575
13	33	-0.0002784	-0.0002762	0.0001007	0.001131	0.0007506	0.0005731
14	15	-0.0003606	0.0005557	0.0004093	0.001141	0.001956	0.003225
15	31	-9.008e-05	-0.0004021	-0.0001989	0.0009667	0.001421	0.007847
16	36	-2.713e-05	0.0007057	0.0002804	0.0009608	0.001967	0.00449
17	38	-0.0001799	0.001014	0.0001279	0.00117	0.00239	0.00511
18	33	-2.196e-05	-0.0004731	-0.0005157	0.001096	0.001546	0.00459
19	36	-0.000793	0.002182	0.0009624	0.001413	0.003109	0.005989
21	8	5.722e-05	2.861e-06	-0.0005766	0.0001112	1.628e-05	0.002082
22	40	-0.0004202	-0.0002098	0.000235	0.001001	0.0008771	0.004383
23	10	2.365e-05	-3.242e-05	-8.106e-07	0.0001752	0.0004443	1.416e-05
24	21	2.434e-05	1.181e-05	-8.919e-05	0.0002191	9.394e-05	0.0003912
25	48	-0.001541	0.0007892	0.0005171	0.002692	0.001888	0.005564
26	20	-0.0004311	0.00135	0.002023	0.001016	0.002738	0.007165
27	13	-0.002722	0.0006426	-0.0003674	0.005181	0.001695	0.00121
28	10	0.0003471	0.0001175	-0.0002916	0.001049	0.0002625	0.001206
30	11	-7.352e-05	-0.0002147	0.001596	0.0003224	0.0009996	0.002761
31	13	0.0002788	7.688e-05	0.0006784	0.001412	0.0006167	0.003089
33	32	-0.0005481	9.346e-05	4.657e-07	0.001462	0.001551	0.005108
34	42	0.0008127	-0.0002405	-2.132e-05	0.001267	0.000986	0.005246
35	35	9.439e-05	0.0007669	0.0001418	0.001545	0.002069	0.001936
36	15	0.0006973	9.155e-06	-0.000172	0.002765	0.001363	0.002988
37	11	-0.0002622	4.543e-05	0.001684	0.00143	0.001038	0.003167
38	27	0.0001079	-3.235e-05	2.378e-05	0.0007039	0.0003934	0.003457
39	43	-2.466e-05	0.0002685	-0.0004812	0.001732	0.001304	0.004771
40	38	0.0002072	0.0002727	0.0003114	0.002548	0.001999	0.001476
41	30	0.0001544	4.056e-05	9.819e-05	0.00163	0.00186	0.004161
42	38	-0.0004363	7.198e-05	-9.888e-06	0.001998	0.001364	0.0001428
43	44	-0.0003418	0.0003353	0.0002628	0.003246	0.001369	0.003787
44	25	-8.667e-05	5.478e-05	9.699e-05	0.0006429	0.0003118	0.003663
45	23	0.0006296	0.0004241	0.0006182	0.002385	0.001645	0.004515
46	25	2.563e-05	2.106e-05	0.0003974	0.0006943	0.0006316	0.005115
48	2	0.001583	-4.005e-05	-4.053e-06	0.002239	5.665e-05	5.732e-06
49	12	0.0001329	1.907e-06	-0.0002344	0.0006838	0.0001307	0.001173
50	18	5.51e-06	4.387e-05	-0.0001947	0.0002101	0.0002262	0.002238
52	42	-0.0005502	0.0005886	7.055e-05	0.002507	0.002498	0.0003804
53	48	-0.001141	0.001259	-0.000443	0.003043	0.002559	0.009126
54	6	-7.502e-05	3.624e-05	-3.179e-06	0.0004389	0.0001129	5.158e-06
56	35	-0.001363	0.0017	-5.204e-05	0.002789	0.003546	0.001081
57	39	0.0001831	-0.0003641	0.0002415	0.002199	0.001279	0.001203
58	11	-0.0003829	4.82e-05	0.001246	0.001372	0.0006522	0.003696
59	15	1.373e-05	1.755e-05	0.0002806	0.0002555	0.0001821	0.002777
60	11	-2.705e-05	3.468e-06	-0.0002294	0.0001179	0.0001228	0.003967
61	32	0.0003078	-0.0004805	0.0001661	0.0008331	0.001322	0.0008243
62	3	-1.526e-05	5.341e-05	-3.378e-07	3.326e-05	0.0002223	5.85e-07
63	26	-0.0004765	0.0002164	0.001049	0.002425	0.001515	0.004914
64	18	7.078e-05	6.527e-05	-5.055e-05	0.0002121	0.0002266	0.003636
69	24	-0.000138	0.0006204	0.0005103	0.001418	0.002128	0.001776
70	9	-6.527e-05	-7.884e-05	0.0005374	9.227e-05	0.0001873	0.0009636
72	2	-0.003529	0.001478	0.0003142	0.00499	0.00209	0.0004444
73	25	-0.000173	0.0005257	-6.916e-05	0.003338	0.002138	0.001889
75	26	-0.0004642	-0.0002064	-0.000405	0.001166	0.002535	0.01003
76	14	-0.00271	0.0007022	0.003814	0.007605	0.003304	0.008696
77	32	0.0003834	-0.000877	0.0009262	0.003955	0.002951	0.002629
83	15	9.054e-05	-5.773e-05	-4.36e-05	0.000836	0.0002539	0.003336
85	2	-0.000248	9.537e-06	-3.302e-05	0.0003507	1.349e-05	4.67e-05
87	4	-0.0003757	0.001352	-1.347e-05	0.0006911	0.002934	1.2e-05
88	14	-0.002534	0.001105	0.003533	0.007791	0.002604	0.0106
92	10	7.629e-07	-0.0005814	0.0007139	0.00313	0.001113	0.003068
94	7	0.0005123	4.905e-05	-4.564e-06	0.001034	0.0001626	7.987e-06
95	4	-0.0001144	-3.338e-05	-0.001238	0.001389	0.0005731	0.002182
96	4	-7.629e-06	1.907e-06	-1.252e-06	2.066e-05	7.633e-05	1.921e-06
101	4	0.0009117	-0.0009184	-7.998e-06	0.001463	0.000807	6.164e-06
102	6	-0.002528	-0.0005067	-0.0008183	0.00356	0.001397	0.002037
104	4	-0.0001163	-5.722e-05	-0.000235	0.0002271	0.0002506	0.0007996
105	3	-4.323e-05	-0.0001272	0.000148	0.0001025	0.0002039	0.0002284
107	3	-0.000679	-2.67e-05	-1.333e-05	0.0006679	0.00016	0.0001176
109	2	0.001282	-0.0009003	3.949e-05	0.001813	0.001273	5.584e-05

Figure 122

TRACK DATA MENU: *Option 5* Continued

Track Number	Number of Associated Detects	Mean ABSOLUTE Innovation Long.	Lat.	Alt.	Standard Deviations Long.	Lat.	Alt.
1	35	0.001735	0.001692	0.004787	0.002406	0.002478	0.006483
2	40	0.002043	0.0009665	0.000573	0.002897	0.001387	0.0007929
3	43	0.0009563	0.001236	0.0008166	0.00135	0.001714	0.001038
4	15	0.0001592	0.0001058	0.0023	0.0002365	0.0001782	0.003489
5	29	0.001364	0.0009134	0.0007378	0.001987	0.001185	0.001183
6	43	0.001428	0.0007392	0.0002936	0.002117	0.001069	0.0004218
7	40	0.001549	0.001023	0.0004569	0.00218	0.001485	0.0006303
9	32	0.001098	0.001095	0.003118	0.00156	0.001606	0.005058
10	45	0.001081	0.001303	0.003131	0.001392	0.00164	0.004035
12	17	0.0002168	0.000149	0.0009221	0.0002704	0.0002549	0.001575
13	33	0.0008568	0.0004699	0.0004303	0.001131	0.0007506	0.0005731
14	15	0.0005122	0.0006523	0.00187	0.001141	0.001956	0.003225
15	31	0.0006443	0.0008638	0.005312	0.0009667	0.001421	0.007847
16	36	0.0007235	0.001567	0.003065	0.0009608	0.001967	0.00449
17	38	0.0007726	0.001895	0.003717	0.00117	0.00239	0.00511
18	33	0.0006688	0.0008389	0.003314	0.001096	0.001546	0.00459
19	36	0.001027	0.002507	0.004649	0.001413	0.003109	0.005989
21	8	8.202e-05	1.144e-05	0.001282	0.0001112	1.628e-05	0.002082
22	40	0.0007601	0.0007015	0.002826	0.001001	0.0008771	0.004383
23	10	0.000132	0.0002529	8.607e-06	0.0001752	0.0004443	1.416e-05
24	21	0.0001755	7.175e-05	0.0001802	0.0002191	9.394e-05	0.0003912
25	48	0.002117	0.001381	0.003478	0.002692	0.001888	0.005564
26	20	0.0005959	0.001478	0.004557	0.001016	0.002738	0.007165
27	13	0.003258	0.001053	0.0004002	0.005181	0.001695	0.00121
28	10	0.0007515	0.0001778	0.000668	0.001049	0.0002625	0.001206
30	11	0.0002483	0.0007147	0.001868	0.0003224	0.0009996	0.002761
31	13	0.001092	0.0004319	0.001632	0.001412	0.0006167	0.003089
33	32	0.001045	0.00118	0.00376	0.001462	0.001551	0.005108
34	42	0.001095	0.0007847	0.003368	0.001267	0.000986	0.005246
35	35	0.001139	0.001542	0.001256	0.001545	0.002069	0.001936
36	15	0.001615	0.0008565	0.001246	0.002765	0.001363	0.002988
37	11	0.0008933	0.0008091	0.002231	0.00143	0.001038	0.003167
38	27	0.0005069	0.0002988	0.002916	0.0007039	0.0003934	0.003457
39	43	0.001211	0.001013	0.003725	0.001732	0.001304	0.004771
40	38	0.001637	0.001452	0.001148	0.002548	0.001999	0.001476
41	30	0.001099	0.001062	0.003207	0.00163	0.00186	0.004161
42	38	0.001451	0.0008755	9.963e-05	0.001998	0.001364	0.0001428
43	44	0.002313	0.001	0.002774	0.003246	0.001369	0.003787
44	25	0.0004828	0.0002388	0.002847	0.0006429	0.0003118	0.003663
45	23	0.001777	0.001178	0.003617	0.002385	0.001645	0.004515
46	25	0.0005188	0.0004788	0.003659	0.0006943	0.0006316	0.005115
48	2	0.001583	4.005e-05	4.053e-06	0.002239	5.665e-05	5.732e-06
49	12	0.0003541	8.456e-05	0.0008649	0.0006838	0.0001307	0.001173
50	18	0.0001462	0.0001464	0.001386	0.0002101	0.0002262	0.002238
52	42	0.001669	0.001808	0.000227	0.002507	0.002498	0.0003804
53	48	0.001967	0.001715	0.004432	0.003043	0.002559	0.009126
54	6	0.0003242	6.294e-05	3.497e-06	0.0004389	0.0001129	5.158e-06
56	35	0.002049	0.002406	0.0007214	0.002789	0.003546	0.001081
57	39	0.001339	0.0009509	0.0008608	0.002199	0.001279	0.001203
58	11	0.001058	0.0004193	0.002867	0.001372	0.0006522	0.003696
59	15	0.0001918	0.0001244	0.001566	0.0002555	0.0001821	0.002777
60	11	6.173e-05	8.254e-05	0.002195	0.0001179	0.0001228	0.003967
61	32	0.0005758	0.0008627	0.0005672	0.0008331	0.001322	0.0008243
62	3	2.035e-05	0.000145	3.378e-07	3.326e-05	0.0002223	5.85e-07
63	26	0.00153	0.0009101	0.003634	0.002425	0.001515	0.004914
64	18	0.0001657	0.0001729	0.002428	0.0002121	0.0002266	0.003636
69	24	0.001045	0.001289	0.001219	0.001418	0.002128	0.001776
70	9	7.206e-05	0.0001305	0.0006752	9.227e-05	0.0001873	0.0009636
72	2	0.003529	0.001478	0.0003142	0.00499	0.00209	0.0004444
73	25	0.00198	0.001449	0.001243	0.003338	0.002138	0.001889
75	26	0.0008117	0.001865	0.007018	0.001166	0.002535	0.01003
76	14	0.005623	0.002307	0.005454	0.007605	0.003304	0.008696
77	32	0.003126	0.002002	0.002106	0.003955	0.002951	0.002629
83	15	0.0006521	0.0001818	0.002259	0.000836	0.0002539	0.003336
85	2	0.000248	9.537e-06	3.302e-05	0.0003507	1.349e-05	4.67e-05
87	4	0.0004864	0.002102	1.347e-05	0.0006911	0.002934	1.2e-05
88	14	0.004692	0.002099	0.005464	0.007791	0.002604	0.0106
92	10	0.002077	0.001002	0.001831	0.00313	0.001113	0.003068
94	7	0.0007542	0.0001068	6.574e-06	0.001034	0.0001626	7.987e-06
95	4	0.000885	0.0003614	0.001329	0.001389	0.0005731	0.002182
96	4	1.144e-05	4.768e-05	1.252e-06	2.066e-05	7.633e-05	1.921e-06
101	4	0.0009117	0.0009184	7.998e-06	0.001463	0.000807	6.164e-06
102	6	0.003337	0.0009632	0.0008434	0.00356	0.001397	0.002037
104	4	0.000185	0.0001545	0.0004695	0.0002271	0.0002506	0.0007996
105	3	6.358e-05	0.0001272	0.000148	0.0001025	0.0002039	0.0002284
107	3	0.000679	0.0001055	7.802e-05	0.0006679	0.00016	0.0001176
109	2	0.001282	0.0009003	3.949e-05	0.001813	0.001273	5.584e-05

Figure 123

TRACK DATA MENU: *Option 5* Continued

Track Number	Number of Associated Detects	Mean Innovation	MAGNITUDE
1	35	0.002811	
2	40	0.002421	
3	43	0.001725	
4	15	0.0002246	
5	29	0.001773	
6	43	0.001769	
7	40	0.002088	
8	1	0	
9	32	0.001773	
10	45	0.001837	
11	1	0	
12	17	0.0003035	
13	33	0.001105	
14	15	0.0009325	
15	31	0.001163	
16	36	0.001906	
17	38	0.002179	
18	33	0.001181	
19	36	0.002883	
20	1	0	
21	8	9.674e-05	
22	40	0.001186	
23	10	0.0003458	
24	21	0.0002104	
25	48	0.002871	
26	20	0.001723	
27	13	0.003737	
28	10	0.0008906	
29	1	0	
30	11	0.0008687	
31	13	0.001362	
32	1	0	
33	32	0.001733	
34	42	0.00152	
35	35	0.002222	
36	15	0.002317	
37	11	0.001441	
38	27	0.0006581	
39	43	0.001727	
40	38	0.00248	
41	30	0.00178	
42	38	0.001811	
43	44	0.002701	
44	25	0.0006109	
45	23	0.002396	
46	25	0.0007835	
47	1	0	
48	2	0.003167	
49	12	0.0004049	
50	18	0.0002433	
51	1	0	
52	42	0.002755	
53	48	0.003022	
54	6	0.0004037	
55	1	0	
56	35	0.003436	
57	39	0.001933	
58	11	0.001331	
59	15	0.0002656	
60	11	0.0001305	
61	32	0.00113	
62	3	0.0002199	
63	26	0.002023	
64	18	0.0002672	
65	1	0	
66	1	0	
67	1	0	
68	1	0	
69	24	0.001857	
70	9	0.0001729	
71	1	0	
72	2	0.007651	
73	25	0.002981	
74	1	0	
75	26	0.002217	

etc.

Figure 124

TRACK DATA MENU: *Option 5* Continued

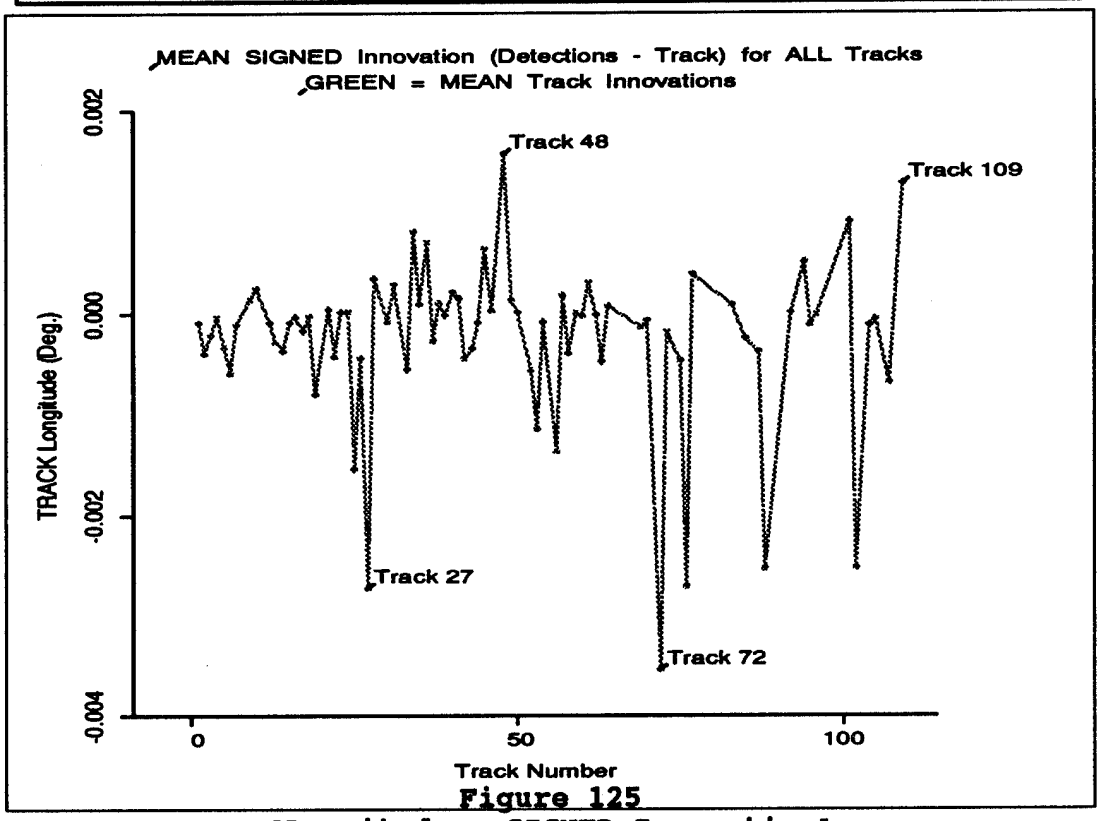


Figure 125

[Longitude - SIGNED Innovation]

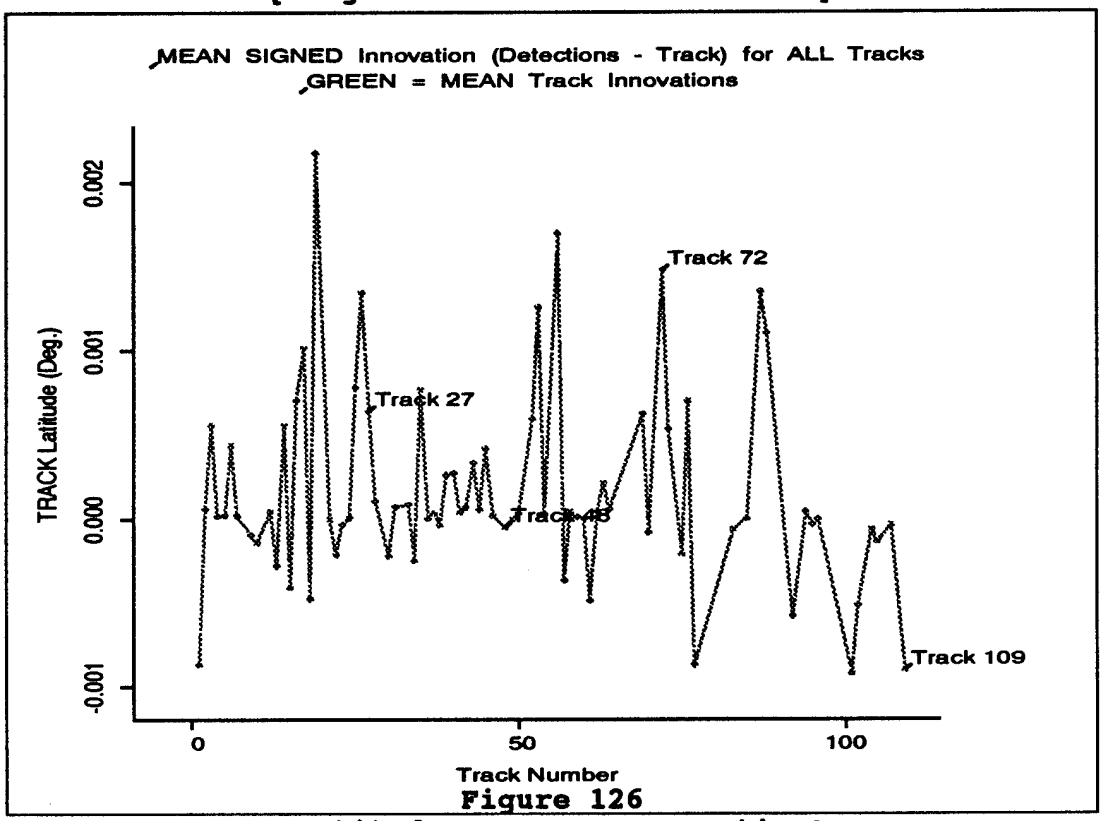


Figure 126

[Latitude - SIGNED Innovation]

TRACK DATA MENU: *Option 5* Continued

```
**********************************************************
MENU for (Detection - Track) Innovation:
     1.  Compute (Detection - Track) Innovation for One Track ONLY
     2.  Compute (Detection - Track) Innovation for ALL TRACKS
MENU Choice:  2
**********************************************************
```

Figure 120 - Repeated

```
*******************************************************
ERROR MENU:
     1.  Compute SIGNED Innovation  (Detection - Calculated Track)
     2.  Compute ABSOLUTE Innovation  ABS(Detection - Calculated Track)
     3.  Compute MAGNITUDE of Innovation  (Lat. & Long. ONLY)
     4.  Compute Innovations in East-North-UP Coordinate System
              and Plot ENU Innovation COMPONENTS and MAGNITUDE
ERROR MENU Choice:  2
*******************************************************
```

Figure 127

```
*****************************************************
Does the User also want to have the Standard Deviations plotted around the MEAN?
    0.  DO NOT PLOT Standard Deviations around the MEAN
    1.  +/- One Standard Deviation    (If Normality Assumed, should include 68.3 per cent of the Data)
    2.  +/- Two Standard Deviations   (If Normality Assumed, should include 95.4 per cent of the Data)
    3.  +/- Three Standard Deviations (If Normality Assumed, should include 99.73 per cent of the Data)
Standard Deviation Choice:  0
*****************************************************
```

Figure 97 - Repeated

This example is the same as the previous example (**Figures 125 and 126** on the previous page) except this time the **ABSOLUTE Innovation** is plotted rather than the SIGNED Innovation. These choices result in the Tables already shown as **Figures 122, 123, and 124** as well as the plots on the next page (**Figures 128 and 129**).

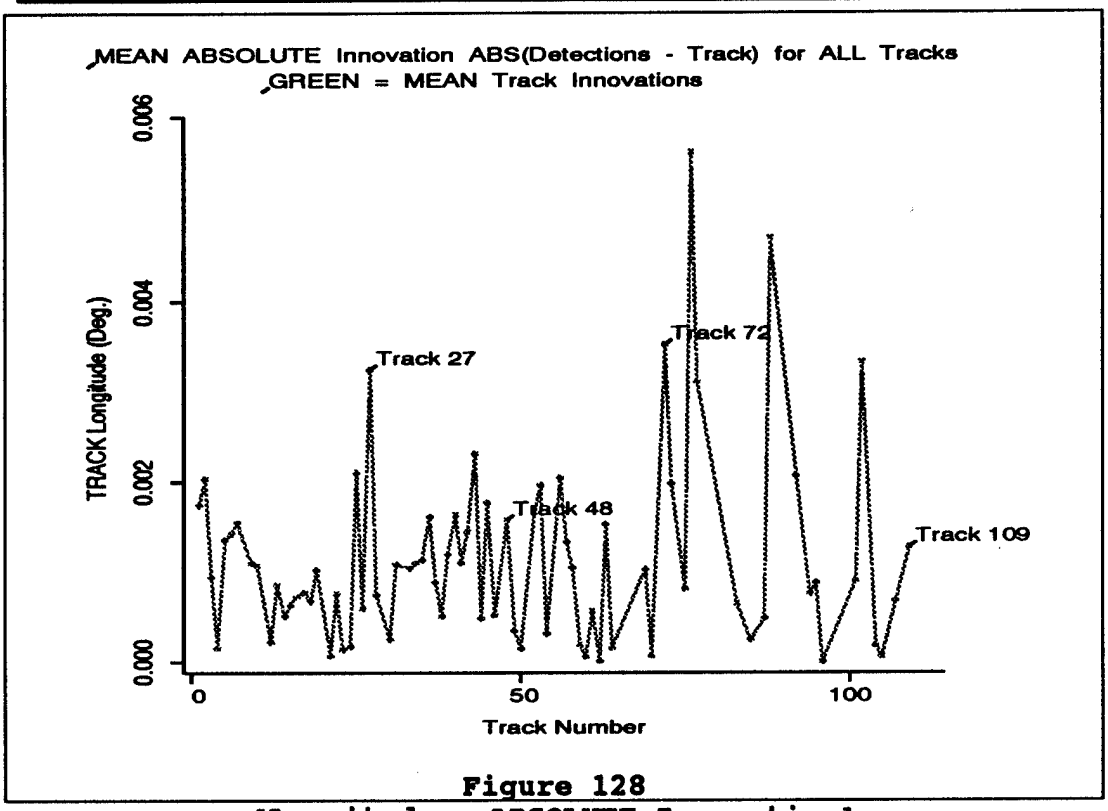


Figure 128
[Longitude - ABSOLUTE Innovation]

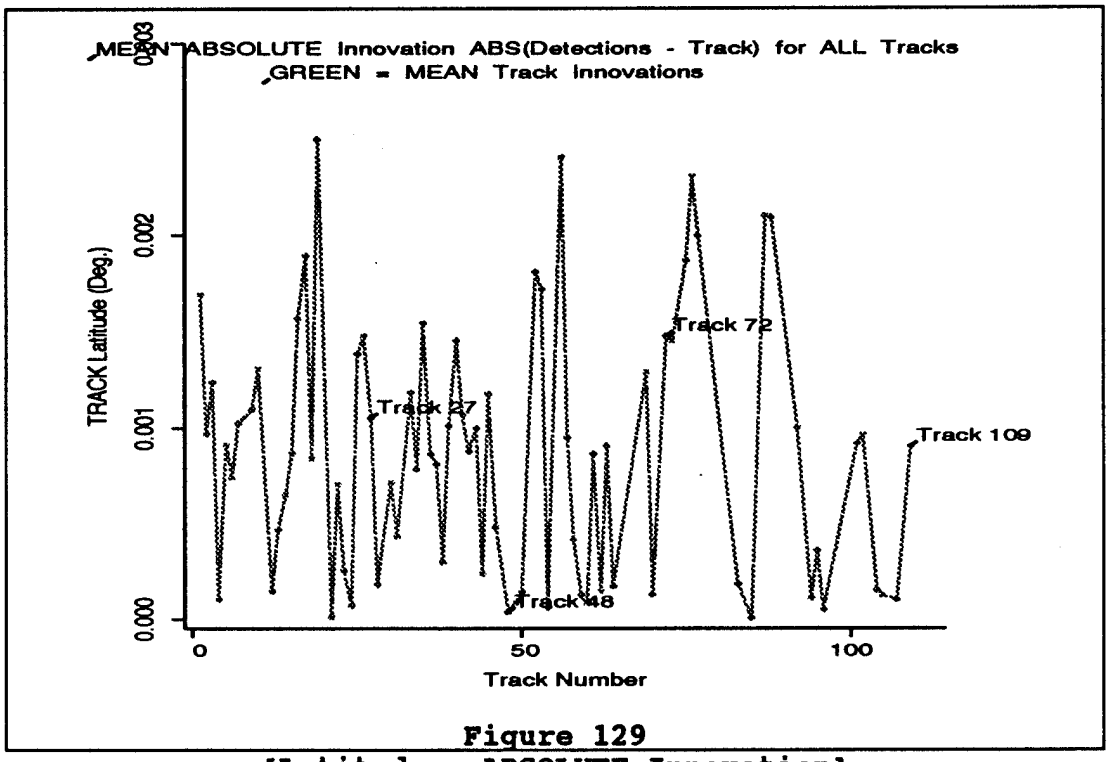


Figure 129
[Latitude - ABSOLUTE Innovation]

TRACK DATA MENU: *Option 5* Continued

```
*********************************************************
MENU for (Detection - Track) Innovation:
     1.  Compute (Detection - Track) Innovation for One Track ONLY
     2.  Compute (Detection - Track) Innovation for ALL TRACKS
MENU Choice:  2
*********************************************************
```

Figure 120 - Repeated

```
*********************************************************
ERROR MENU:
     1.  Compute SIGNED Innovation  (Detection - Calculated Track)
     2.  Compute ABSOLUTE Innovation  ABS(Detection - Calculated Track)
     3.  Compute MAGNITUDE of Innovation  (Lat. & Long. ONLY)
     4.  Compute Innovations in East-North-UP Coordinate System
           and Plot ENU Innovation COMPONENTS and MAGNITUDE
ERROR MENU Choice:  3
*********************************************************
```

Figure 130

Option 5 from the **TRACK DATA MENU** continues to be exercised. In this case, the Innovations for all Tracks are chosen to be displayed from **Figure 120 - Repeated** and the **Innovation MAGNITUDE** (using only Latitude and Longitude) is chosen from **Figure 130.** These choices result in the Tables already shown as **Figures 122, 123, and 124** as well as the plot on the following page (**Figure 131**).

TRACK DATA MENU: *Option 5* Continued

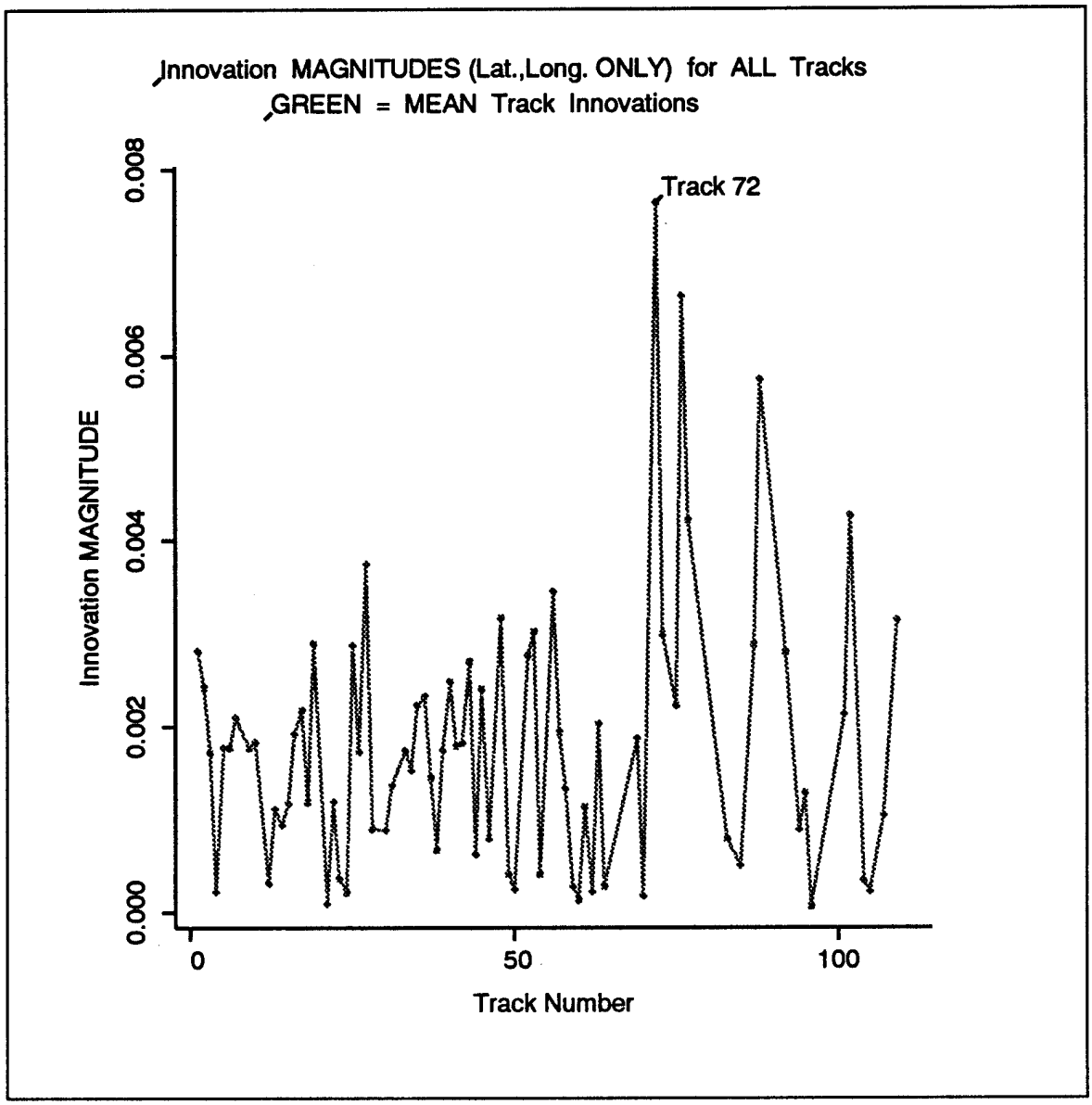


Figure 131

TRACK DATA MENU: *Option 5* Continued

```
**********************************************************
MENU for (Detection - Track) Innovation:
     1.  Compute (Detection - Track) Innovation for One Track ONLY
     2.  Compute (Detection - Track) Innovation for ALL TRACKS
MENU Choice:  2
**********************************************************
```

Figure 120 – Repeated

```
*****************************************************
ERROR MENU:
     1.  Compute SIGNED Innovation  (Detection - Calculated Track)
     2.  Compute ABSOLUTE Innovation  ABS(Detection - Calculated Track)
     3.  Compute MAGNITUDE of Innovation  (Lat. & Long. ONLY)
     4.  Compute Innovations in East-North-UP Coordinate System
              and Plot ENU Innovation COMPONENTS and MAGNITUDE
ERROR MENU Choice:  4
*****************************************************
```

Figure 109 – Repeated

```
*******************************************************
ENU Component ERROR MENU:
     1.  Compute SIGNED  ENU  Innovation
     2.  Compute ABSOLUTE  ENU  Innovation
ENU Component ERROR MENU Choice:  1
*******************************************************
```

Figure 110 – Repeated

When invoking *Option 5* from the **TRACK DATA MENU**, the User has the Option of observing the East-North-Up Innovations for ALL TRACKS created by a particular Algorithm (**Figures 120, 109, and 110** above). Tables are first displayed at the User's shell which summarize the SIGNED and ABSOLUTE innovations (**Figures 132, 133, and 134** on the next three pages) and then the plots will be displayed via XGobi (**Figures 135, 136, 137, and 138** for the SIGNED ENU Innovations and **Figures 139, 140, and 141** for the ABSOLUTE ENU Innovations).

TRACK DATA MENU: Option 5 Continued

Track Number	Number of Associated Detects	Mean SIGNED Innovation Components EAST	NORTH	UP	Standard Deviations EAST	NORTH	UP
			page 1				
1	35	-3.65e-05	-1.626e-05	-0.001024	0.0001056	0.0004162	0.00648
2	40	1.593e-06	-3.569e-05	0.0001769	2.98e-05	0.0002698	0.000792
3	43	1.717e-05	-2.642e-05	7.056e-05	5.24e-05	0.0001688	0.00103
4	15	1.139e-07	-7.68e-07	0.0003227	8.687e-07	4.631e-06	0.00348
5	29	1.158e-06	-5.809e-05	0.000366	4.962e-05	0.0003646	0.00118
6	43	1.614e-05	-9.528e-05	-3.27e-05	3.917e-05	0.0003435	0.000421
7	40	9.999e-07	-1.726e-05	7.195e-05	6.035e-05	0.000377	0.000630
9	32	-1.628e-06	1.158e-05	0.0001907	2.882e-05	0.0001251	0.00505
10	45	-6.652e-07	6.762e-06	0.0001163	1.103e-05	3.999e-05	0.00403
12	17	6.466e-08	-4.731e-07	-0.0002022	3.271e-07	1.488e-06	0.00157
13	33	-3.701e-06	-1.659e-05	0.0001007	1e-05	6.739e-05	0.000573
14	15	6.547e-06	-1.815e-05	0.0004093	2.243e-05	5.244e-05	0.00322
15	31	-2.008e-06	-2.521e-06	-0.0001989	6.296e-06	1.921e-05	0.00784
16	36	1.097e-05	-1.362e-06	0.0002804	3.027e-05	5.932e-05	0.0044
17	38	7.863e-06	-5.923e-06	0.0001279	1.85e-05	3.819e-05	0.0051
18	33	-4.306e-06	-1.218e-06	-0.0005157	1.413e-05	4.609e-05	0.0045
19	36	3.213e-05	-4.716e-05	0.0009624	4.642e-05	8.491e-05	0.00598
21	8	5.459e-09	4.068e-07	-0.0005766	2.062e-08	8.201e-07	0.00208
22	40	-6.6e-07	-5.878e-06	0.000235	2.736e-06	1.391e-05	0.00438
23	10	-2.361e-07	7.044e-07	-8.106e-07	3.236e-06	5.218e-06	1.416e-0
24	21	4.004e-08	3.365e-07	-8.919e-05	3.171e-07	3.03e-06	0.000391
25	48	7.608e-06	-6.226e-05	0.0005171	1.818e-05	0.0001085	0.00556
26	20	1.48e-05	-1.885e-05	0.002023	3.061e-05	4.29e-05	0.00716
27	13	1.18e-05	-0.0002042	-0.0003674	3.109e-05	0.0003886	0.0012
28	10	1.009e-06	1.189e-05	-0.0002916	2.257e-06	3.603e-05	0.00120
30	11	-5.065e-07	-4.866e-07	0.001596	1.709e-06	2.294e-06	0.00276
31	13	2.892e-07	2.344e-06	0.0006784	2.127e-06	1.986e-05	0.00308
33	32	3.691e-07	-1.143e-05	4.652e-07	7.95e-06	3.107e-05	0.00510
34	42	-4.298e-06	6.287e-05	-2.132e-05	1.774e-05	9.799e-05	0.00524
35	35	2.039e-05	1.03e-05	0.0001418	5.486e-05	0.0001684	0.00193
36	15	3.58e-07	0.0001201	-0.0001721	5.998e-05	0.0004764	0.00298
37	11	4.641e-07	-8.504e-06	0.001684	6.408e-06	3.808e-05	0.00316
38	27	-1.421e-07	2.173e-06	2.378e-05	1.454e-06	1.267e-05	0.00345
39	43	1.194e-05	-6.044e-07	-0.0004812	5.935e-05	0.0003309	0.00477
40	38	1.223e-05	3.807e-05	0.0003114	8.906e-05	0.0004677	0.00147
41	30	1.268e-06	7.699e-06	9.819e-05	3.194e-05	0.000111	0.00416
42	38	1.707e-06	-4.526e-05	-9.892e-06	3.242e-05	0.0002073	0.000142
43	44	1.411e-05	-5.795e-05	0.0002628	5.826e-05	0.0005856	0.00378
44	25	1.133e-07	-1.146e-06	9.699e-05	9.178e-07	9.379e-06	0.00366
45	23	1.018e-05	6.443e-05	0.0006182	3.972e-05	0.0002384	0.00451
46	25	6.429e-08	2.203e-07	0.0003974	1.665e-06	7.712e-06	0.00511
48	2	-4.398e-07	6.83e-05	-4.055e-06	6.22e-07	9.659e-05	5.735e-0
49	12	1.365e-08	6.258e-06	-0.0002344	1.496e-06	3.138e-05	0.00117
50	18	8.124e-08	4.172e-08	-0.0001947	4.17e-07	1.491e-06	0.00223
52	42	3.29e-05	-0.0001302	7.054e-05	0.0001374	0.0005935	0.000380
53	48	2.271e-05	-8.556e-05	-0.0004431	4.618e-05	0.0002275	0.00912
54	6	2.32e-07	-2.035e-06	-3.179e-06	7.233e-07	1.191e-05	5.158e-0
56	35	7.813e-05	-0.00025	-5.206e-05	0.0001631	0.0005117	0.00108
57	39	-1.545e-05	3.166e-05	0.0002415	5.411e-05	0.0003801	0.00120
58	11	-1.455e-07	-3.727e-06	0.001246	1.729e-06	1.896e-05	0.00369
59	15	2.427e-08	7.35e-08	0.0002806	2.511e-07	1.478e-06	0.00277
60	11	-1.279e-08	-6.128e-07	-0.0002294	3.346e-07	2.401e-06	0.00396
61	32	-1.807e-05	5.319e-05	0.0001661	4.95e-05	0.000144	0.000824
62	3	6.775e-08	-8.098e-08	-3.378e-07	2.821e-07	1.765e-07	5.85e-0
63	26	7.66e-06	-5.57e-05	0.001049	5.143e-05	0.0003223	0.00491
64	18	9.281e-08	3.845e-07	-5.055e-05	3.102e-07	1.248e-06	0.00363
69	24	9.018e-06	-8.063e-06	0.0005103	3.091e-05	8.293e-05	0.00177
70	9	-7.279e-08	-2.413e-07	0.0005374	1.75e-07	3.382e-07	0.000963
72	2	4.59e-05	-0.0005109	0.0003142	6.491e-05	0.0007225	0.000444
73	25	1.925e-05	-2.528e-05	-6.917e-05	7.862e-05	0.0004881	0.00188
			page 2				
75	26	-1.79e-06	-2.519e-05	-0.000405	2.655e-05	5.925e-05	0.0100
76	14	2.093e-05	-0.0003655	0.003814	9.655e-05	0.001032	0.00869
77	32	-4.01e-05	7.072e-05	0.0009261	0.0001354	0.0007283	0.00262
83	15	-1.372e-07	9.478e-07	-4.36e-05	7.013e-07	1.039e-05	0.00333
85	2	4.167e-08	-4.616e-06	-3.302e-05	5.893e-08	6.529e-06	4.67e-0
87	4	1.221e-05	-1.615e-05	-1.347e-05	2.648e-05	2.971e-05	1.2e-0
88	14	2.428e-05	-0.0002338	0.003533	6.1e-05	0.0007956	0.010
92	10	-1.369e-06	-3.713e-07	0.0007139	2.617e-06	3.436e-05	0.00306
94	7	4.273e-07	1.774e-05	-4.564e-06	1.42e-06	3.582e-05	7.987e-0
95	4	-6.136e-07	-7.941e-06	-0.001238	8.388e-06	8.013e-05	0.00218
96	4	1.391e-08	-2.272e-07	-1.252e-06	5.563e-07	6.154e-07	1.921e-0
101	4	-4.4e-07	1.982e-06	-7.998e-06	3.866e-07	3.18e-06	6.164e-0
102	6	-1.865e-05	-0.0003774	-0.0008183	5.135e-05	0.0005323	0.00203
104	4	-3.031e-07	-2.537e-06	-0.000235	1.325e-06	4.952e-06	0.000799
105	3	-1.515e-07	-2.233e-07	0.000148	2.492e-07	4.736e-07	0.000228
107	3	-5.485e-08	-8.806e-06	-1.333e-05	4.673e-07	8.243e-06	0.000117
109	2	-2.077e-06	1.372e-05	3.949e-05	2.938e-06	1.94e-05	5.584e-0

Figure 132

TRACK DATA MENU: Option 5 Continued

Track Number	Number of Associated Detects	Mean ABSOLUTE Innovation Components EAST	NORTH	UP	Standard Deviations EAST	NORTH	UP
				page 3			
1	35	7.21e-05	0.0003001	0.004787	0.0001056	0.0004162	0.006483
2	40	2.082e-05	0.0001902	0.000573	2.98e-05	0.0002698	0.0007929
3	43	3.771e-05	0.0001195	0.0008166	5.24e-05	0.0001688	0.001038
4	15	5.159e-07	3.131e-06	0.0023	8.687e-07	4.631e-06	0.003489
5	29	3.813e-05	0.0002504	0.0007378	4.962e-05	0.0003646	0.001183
6	43	2.711e-05	0.0002317	0.0002936	3.917e-05	0.0003435	0.0004218
7	40	4.132e-05	0.0002677	0.0004569	6.035e-05	0.000377	0.0006303
9	32	1.962e-05	8.808e-05	0.003118	2.882e-05	0.0001251	0.005058
10	45	8.657e-06	3.066e-05	0.003131	1.103e-05	3.999e-05	0.004035
12	17	1.957e-07	1.205e-06	0.0009221	3.271e-07	1.488e-06	0.001575
13	33	6.268e-06	5.104e-05	0.0004303	1e-05	6.739e-05	0.0005731
14	15	7.033e-06	2.076e-05	0.00187	2.243e-05	5.244e-05	0.003225
15	31	3.129e-06	1.047e-05	0.005312	6.296e-06	1.921e-05	0.007847
16	36	2.396e-05	4.514e-05	0.003065	3.027e-05	5.932e-05	0.00449
17	38	1.467e-05	2.521e-05	0.003717	1.85e-05	3.819e-05	0.00511
18	33	7.606e-06	2.767e-05	0.003314	1.413e-05	4.609e-05	0.00459
19	36	3.665e-05	6.011e-05	0.004649	4.642e-05	8.491e-05	0.005989
21	8	1.346e-08	5.133e-07	0.001282	2.062e-08	8.201e-07	0.002082
22	40	2.19e-06	1.056e-05	0.002826	2.736e-06	1.391e-05	0.004383
23	10	1.842e-06	3.931e-06	8.607e-06	3.236e-06	5.218e-06	1.416e-05
24	21	2.42e-07	2.426e-06	0.0001802	3.171e-07	3.03e-06	0.0003912
25	48	1.33e-05	8.523e-05	0.003478	1.818e-05	0.0001085	0.005564
26	20	1.594e-05	2.515e-05	0.004557	3.061e-05	4.29e-05	0.007165
27	13	1.934e-05	0.0002444	0.0004002	3.109e-05	0.0003886	0.00121
28	10	1.527e-06	2.581e-05	0.000668	2.257e-06	3.603e-05	0.001206
30	11	1.112e-06	1.572e-06	0.001868	1.709e-06	2.294e-06	0.002761
31	13	1.359e-06	1.463e-05	0.001632	2.127e-06	1.986e-05	0.003089
33	32	5.788e-06	2.205e-05	0.00376	7.95e-06	3.107e-05	0.005108
34	42	1.412e-05	8.465e-05	0.003368	1.774e-05	9.799e-05	0.005246
35	35	4.088e-05	0.0001242	0.001256	5.486e-05	0.0001684	0.001936
36	15	3.774e-05	0.0002782	0.001246	5.998e-05	0.0004764	0.002988
37	11	4.789e-06	2.275e-05	0.002231	6.408e-06	3.808e-05	0.003167
38	27	1.083e-06	8.549e-06	0.002916	1.454e-06	1.267e-05	0.003457
39	43	4.621e-05	0.000234	0.003725	5.935e-05	0.0003309	0.004771
40	38	6.465e-05	0.0003005	0.001148	8.906e-05	0.0004677	0.001476
41	30	1.809e-05	7.371e-05	0.003207	3.194e-05	0.000111	0.004161
42	38	2.077e-05	0.0001505	9.963e-05	3.242e-05	0.0002073	0.0001428
43	44	4.25e-05	0.0004161	0.002774	5.826e-05	0.0005856	0.003787
44	25	7.195e-07	6.905e-06	0.002847	9.178e-07	9.379e-06	0.003663
45	23	2.846e-05	0.0001772	0.003617	3.972e-05	0.0002384	0.004515
46	25	1.227e-06	5.594e-06	0.003659	1.665e-06	7.712e-06	0.005115
48	2	4.398e-07	6.83e-05	4.055e-06	6.22e-07	9.659e-05	5.735e-06
49	12	9.595e-07	1.598e-05	0.0008649	1.496e-06	3.138e-05	0.001173
50	18	2.687e-07	1.056e-06	0.001386	4.17e-07	1.491e-06	0.002238
52	42	0.0001001	0.0003951	0.000227	0.0001374	0.0005935	0.0003804
53	48	3.111e-05	0.0001465	0.004432	4.618e-05	0.0002275	0.009126
54	6	4.033e-07	8.797e-06	3.497e-06	7.233e-07	1.191e-05	5.158e-06
56	35	0.0001109	0.0003759	0.0007214	0.0001631	0.0005117	0.001081
57	39	4.014e-05	0.0002315	0.0008608	5.411e-05	0.0003801	0.001203
58	11	1.138e-06	1.447e-05	0.002867	1.729e-06	1.896e-05	0.003696
59	15	1.719e-07	1.105e-06	0.001566	2.511e-07	1.478e-06	0.002777
60	11	2.438e-07	1.041e-06	0.002195	3.346e-07	2.401e-06	0.003967
61	32	3.243e-05	9.953e-05	0.0005672	4.95e-05	0.000144	0.0008243
62	3	1.839e-07	1.08e-07	3.378e-07	2.821e-07	1.765e-07	5.85e-07
63	26	3.016e-05	0.0001998	0.003634	5.143e-05	0.0003223	0.004914
64	18	2.33e-07	9.274e-07	0.002428	3.102e-07	1.248e-06	0.003636
69	24	1.876e-05	6.109e-05	0.001219	3.091e-05	8.293e-05	0.001776
70	9	1.199e-07	2.585e-07	0.0006752	1.75e-07	3.382e-07	0.0009636
72	2	4.59e-05	0.0005109	0.0003142	6.491e-05	0.0007225	0.0004444
73	25	5.335e-05	0.0002895	0.001243	7.862e-05	0.0004881	0.001889

Track Number	Number of Associated Detects	Mean ABSOLUTE Innovation Components EAST	NORTH	UP	Standard Deviations EAST	NORTH	UP
				page 4			
75	26	1.905e-05	3.954e-05	0.007018	2.655e-05	5.925e-05	0.01003
76	14	6.784e-05	0.000766	0.005454	9.655e-05	0.001032	0.008696
77	32	9.195e-05	0.0005755	0.002106	0.0001354	0.0007283	0.002629
83	15	5.103e-07	8.209e-06	0.002259	7.013e-07	1.039e-05	0.003336
85	2	4.167e-08	4.616e-06	3.302e-05	5.893e-08	6.529e-06	4.67e-05
87	4	1.898e-05	2.091e-05	1.347e-05	2.648e-05	2.971e-05	1.2e-05
88	14	4.965e-05	0.0004893	0.005464	6.1e-05	0.0007956	0.0106
92	10	2.395e-06	2.283e-05	0.001831	2.617e-06	3.436e-05	0.003068
94	7	9.329e-07	2.612e-05	6.574e-06	1.42e-06	3.582e-05	7.987e-06
95	4	5.253e-06	5.056e-05	0.001329	8.388e-06	8.013e-05	0.002182
96	4	3.475e-07	3.409e-07	1.252e-06	5.563e-07	6.154e-07	1.921e-06
101	4	4.4e-07	1.982e-06	7.998e-06	3.866e-07	3.18e-06	6.164e-06
102	6	3.543e-05	0.0004992	0.0008434	5.135e-05	0.0005323	0.002037
104	4	8.169e-07	4.034e-06	0.0004695	1.325e-06	4.952e-06	0.0007996
105	3	1.515e-07	2.882e-07	0.000148	2.492e-07	4.736e-07	0.0002284
107	3	3.099e-07	8.806e-06	7.802e-05	4.673e-07	8.243e-06	0.0001176
109	2	2.077e-06	1.372e-05	3.949e-05	2.938e-06	1.94e-05	5.584e-05

Figure 133

TRACK DATA MENU: *Option 5* Continued

Track Number	Number of Associated Detects	page 5 Innovation MAGNITUDE [ENU Components]
1	35	0.004975
2	40	0.0006437
3	43	0.0008708
4	15	0.002464
5	29	0.0008723
6	43	0.0004467
7	40	0.0006002
8	1	0
9	32	0.003229
10	45	0.003203
11	1	0
12	17	0.0009798
13	33	0.0004553
14	15	0.002004
15	31	0.005489
16	36	0.003161
17	38	0.003818
18	33	0.003418
19	36	0.004786
20	1	0
21	8	0.001465
22	40	0.002899
23	10	1.167e-05
24	21	0.0001898
25	48	0.003587
26	20	0.004798
27	13	0.0006478
28	10	0.0007563
29	1	0
30	11	0.002055
31	13	0.001774
32	1	0
33	32	0.003882
34	42	0.003467
35	35	0.001335
36	15	0.001585
37	11	0.002462
38	27	0.003031
39	43	0.00386
40	38	0.001274
41	30	0.003321
42	38	0.0002056
43	44	0.002967
44	25	0.002966
45	23	0.003825
46	25	0.003813
47	1	0
48	2	0.0001368
49	12	0.0009511
50	18	0.001468
51	1	0
52	42	0.00054
53	48	0.004554
54	6	1.219e-05
55	1	0
56	35	0.0009482
57	39	0.0009901
58	11	0.003154
59	15	0.001678
60	11	0.002415

Track Number	Number of Associated Detects	page 6 Innovation MAGNITUDE ENU Components
61	32	0.0006123
62	3	6.484e-07
63	26	0.003836
64	18	0.002571
65	1	0
66	1	0
67	1	0
68	1	0
69	24	0.001298
70	9	0.0007596
71	1	0
72	2	0.001203
73	25	0.001441
74	1	0
75	26	0.007299
76	14	0.006006
77	32	0.002322
78	1	0
79	1	0
80	1	0
81	1	0
82	1	0
83	15	0.002421
84	1	0
85	2	6.668e-05
86	1	0
87	4	4.206e-05
88	14	0.005992
89	1	0
90	1	0
91	1	0
92	10	0.002036
93	1	0
94	7	3.377e-05
95	4	0.001778
96	4	1.827e-06
97	1	0
98	1	0
99	1	0
100	1	0
101	4	1.119e-05
102	6	0.001527
103	1	0
104	4	0.0006265
105	3	0.000222
106	1	0
107	3	0.0001179
108	1	0
109	2	8.371e-05
110	1	0

Figure 134

TRACK DATA MENU: *Option 5* Continued

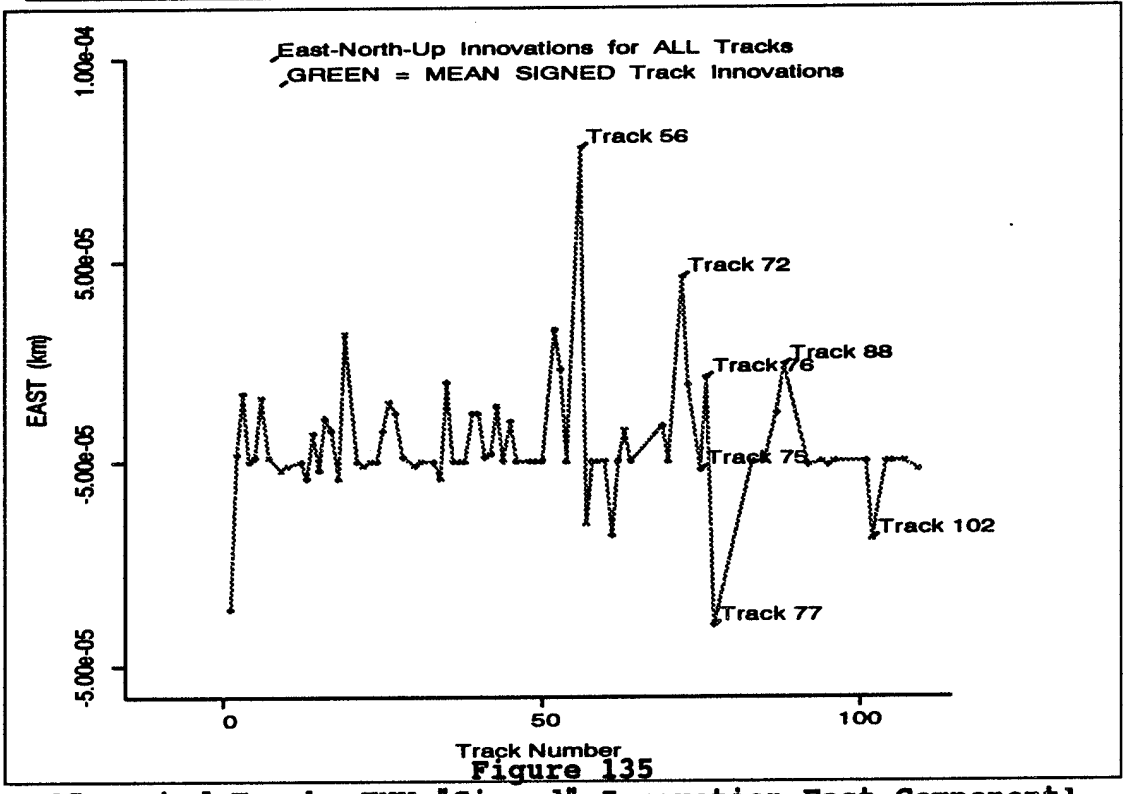


Figure 135

[Computed Tracks ENU "Signed" Innovation East Component]

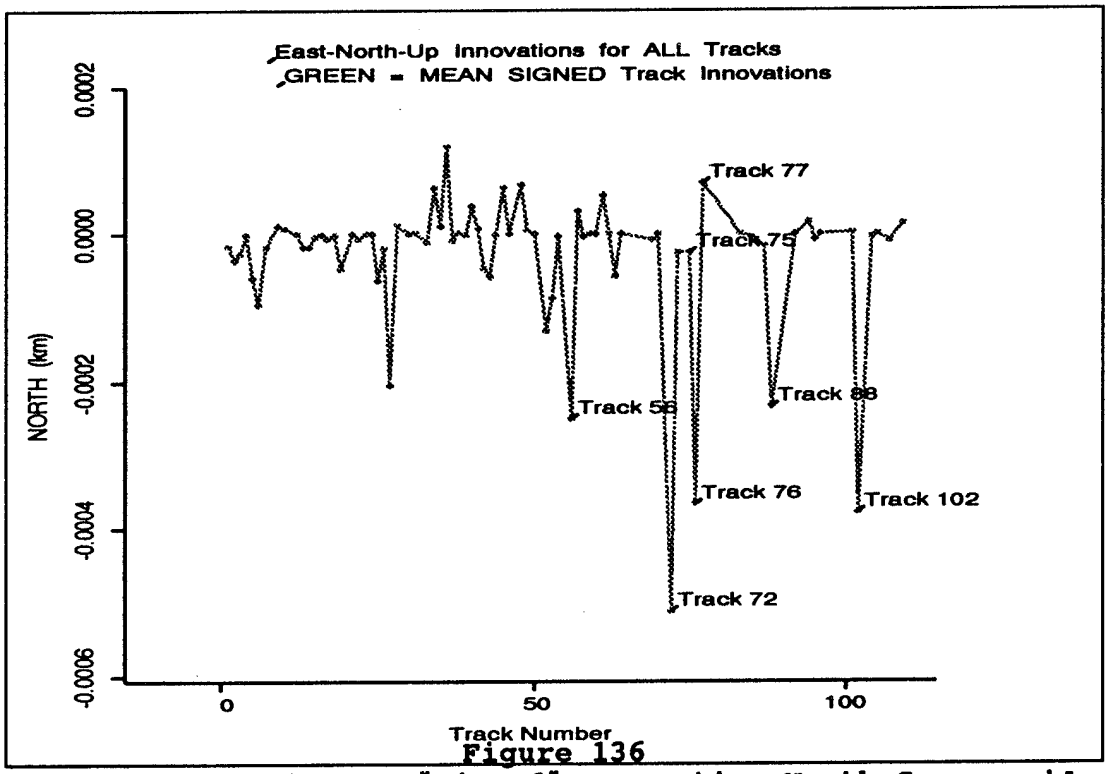


Figure 136

[Computed Tracks ENU "Signed" Innovation North Component]

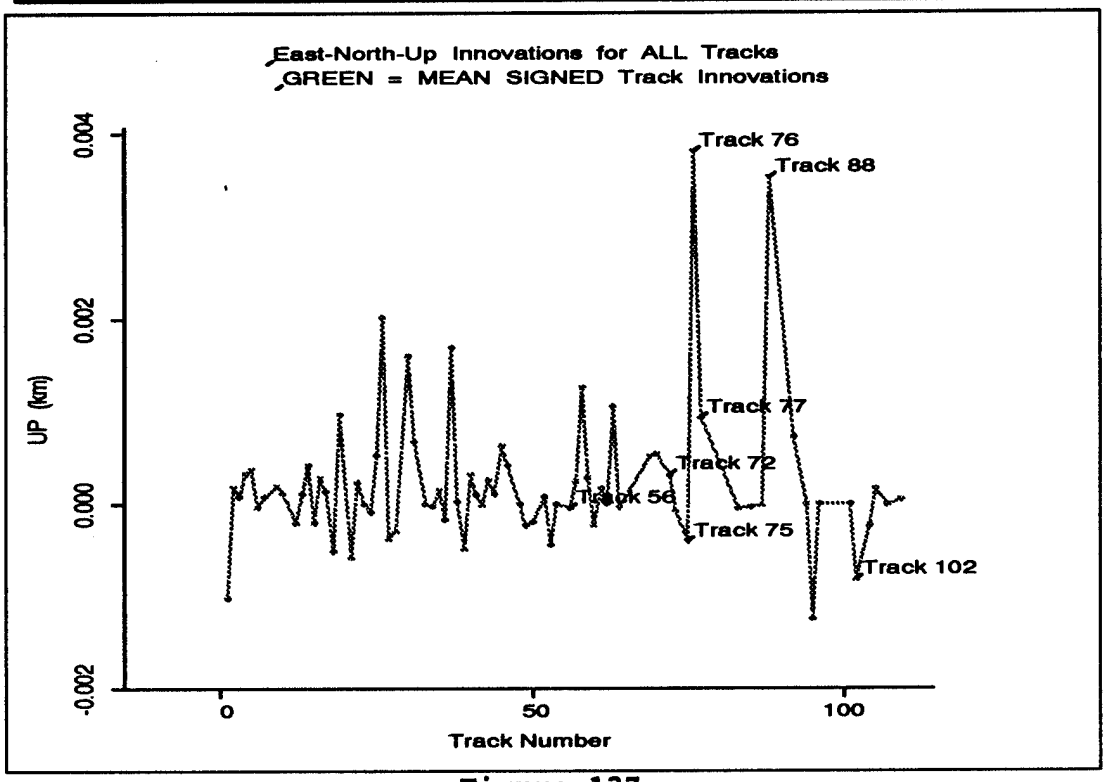


Figure 137
[Computed Tracks ENU "Signed" Innovation Up Component]

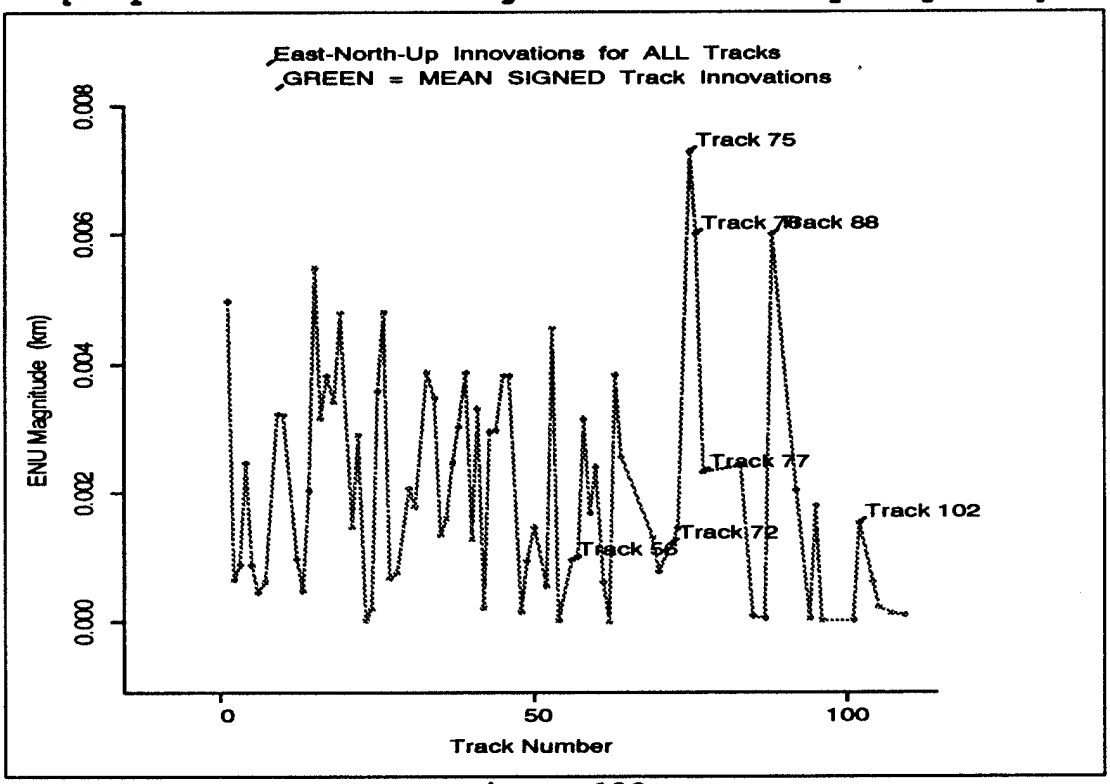


Figure 138
[Computed Tracks ENU MAGNITUDE]

TRACK DATA MENU: *Option 5* Continued

```
**********************************************************
ERROR MENU:
     1.  Compute SIGNED Innovation  (Detection - Calculated Track)
     2.  Compute ABSOLUTE Innovation  ABS(Detection - Calculated Track)
     3.  Compute MAGNITUDE of Innovation  (Lat. & Long. ONLY)
     4.  Compute Innovations in East-North-UP Coordinate System
              and Plot ENU Innovation COMPONENTS and MAGNITUDE
ERROR MENU Choice:  4
**********************************************************
```

Figure 109 - Repeated

```
*****************************************************
ENU Component ERROR MENU:
     1.  Compute SIGNED  ENU  Innovation
     2.  Compute ABSOLUTE  ENU  Innovation
ENU Component ERROR MENU Choice:  2
*****************************************************
```

Figure 115 - Repeated

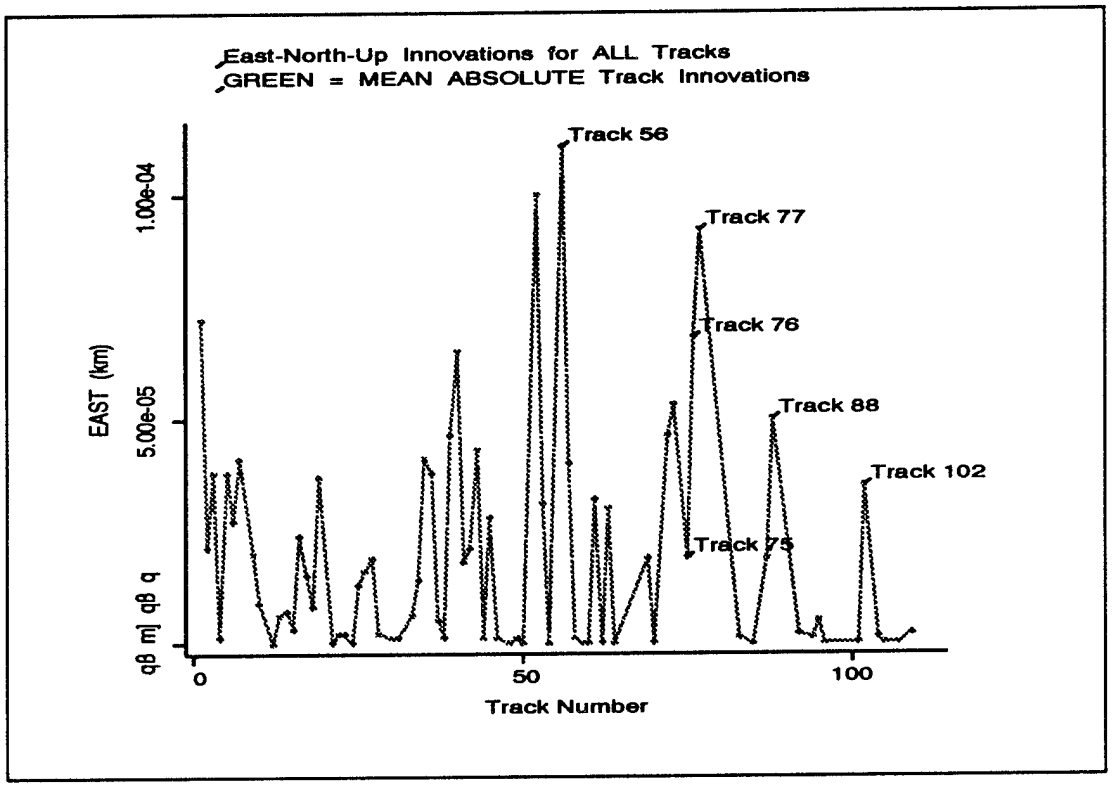


Figure 139
[Computed Tracks ENU "Absolute" Innovation East Component]

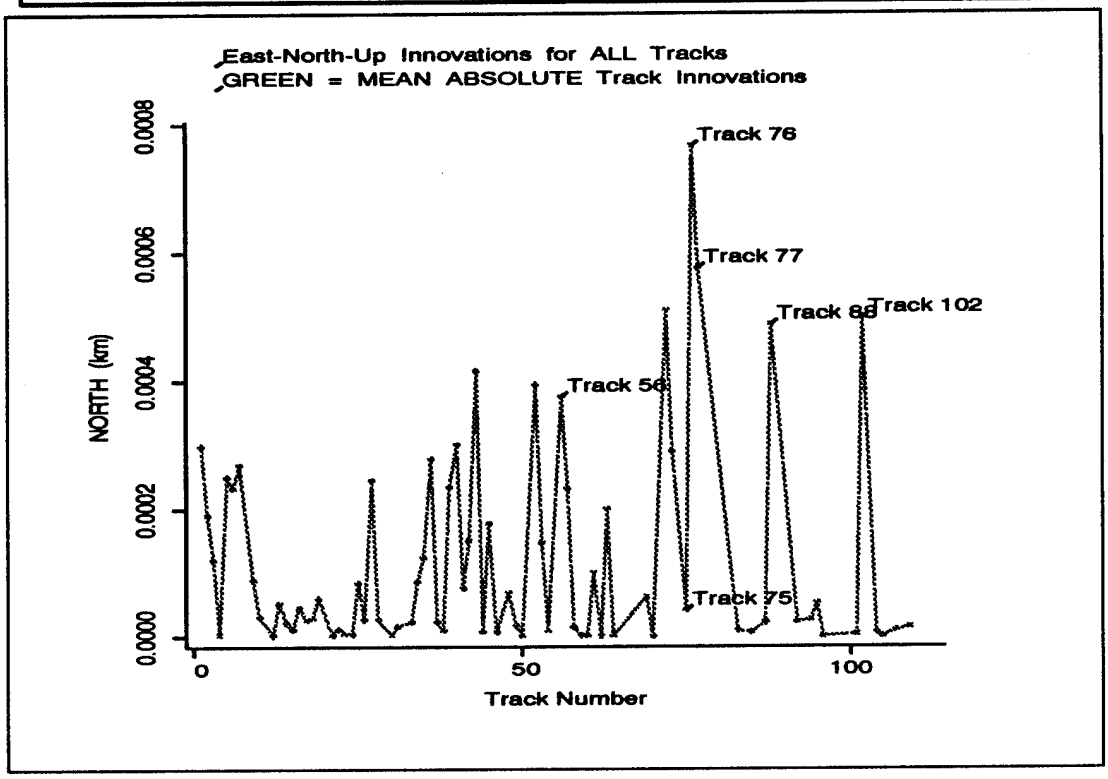


Figure 140
[Computed Tracks ENU "Absolute" Innovation North Component]

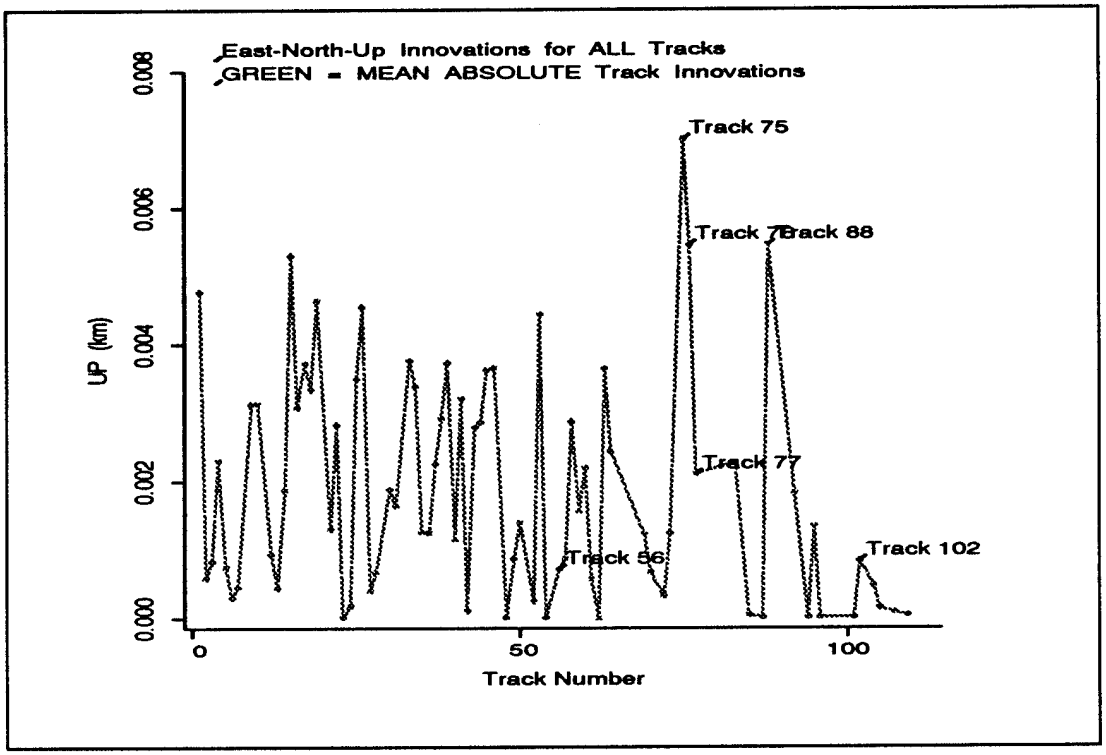


Figure 141
[Computed Tracks ENU "Absolute" Innovation Up Component]

TRACK DATA MENU: *Option 6*

```
Track Data MENU 2:
  0.  PLOT Tracks
  1.  Output Tables by Track Numbers containing Number of Associated Detections and:
      a.  Minimum time and Maximum time
      b.  Range of Track Coordinates
  2.  PLOT One Track
  3.  PLOT One Track and Associated Detections
  4.  PLOT Association Cost
  5.  COMPUTE TABULAR Summary of Innovation (Detections - Track) along with corresponding plot.
  6.  OUTPUT a Table of Target ID vs. Associated Tracks
  7.  PLOT Track Covariances vs. Time
  8.  PLOT Covariance Ellipses for Detections vs. Tracks
  9.  PRINT OUT (by time tick) Selected Data Corresponding to a Particular Track
 10.  PLOT ALL Track Points Corresponding to a Particular Target ID
 11.  PLOT Velocity by Track
 12.  TRANSFER to Scan Data Menu
 13.  QUIT
MENU Choice:  6
```

Figure 141

Option 6 results in a Tabular Display of all Target ID Numbers (sorted in numerical order) and Track Numbers which have been associated by the Algorithm with that particular Target ID. (**Figure 142** on the next page.)

TRACK DATA MENU: *Option 6* Continued

```
                Table of Target ID vs. Associated Tracks

Target 88 was Associated with Tracks  46
Target 112 was Associated with Tracks  31
Target 117 was Associated with Tracks  101
Target 139 was Associated with Tracks  109
Target 149 was Associated with Tracks  37
Target 161 was Associated with Tracks  69
Target 193 was Associated with Tracks  105
Target 204 was Associated with Tracks  64
Target 299 was Associated with Tracks  62, 90
Target 300 was Associated with Tracks  59
Target 321 was Associated with Tracks  38
Target 427 was Associated with Tracks  87, 103
Target 623 was Associated with Tracks  32, 52, 67
Target 640 was Associated with Tracks  10, 12, 22, 23, 24, 28, 38, 44, 50, 65,
                                                    70, 85, 94, 96, 4, 46
Target 642 was Associated with Tracks  41, 92
Target 705 was Associated with Tracks  8, 57
Target 837 was Associated with Tracks  4
Target 871 was Associated with Tracks  5
Target 883 was Associated with Tracks  45
Target 916 was Associated with Tracks  102
Target 980 was Associated with Tracks  83
Target 1058 was Associated with Tracks  13
Target 1068 was Associated with Tracks  11, 51
Target 1073 was Associated with Tracks  16, 98
Target 1085 was Associated with Tracks  54
Target 1162 was Associated with Tracks  29, 55
Target 1163 was Associated with Tracks  33
Target 1164 was Associated with Tracks  35
Target 1183 was Associated with Tracks  61, 71
Target 1215 was Associated with Tracks  97
Target 1521 was Associated with Tracks  40, 7
Target 1530 was Associated with Tracks  107
Target 1557 was Associated with Tracks  9
Target 1692 was Associated with Tracks  30
Target 1762 was Associated with Tracks  47, 63
Target 1764 was Associated with Tracks  74
Target 1778 was Associated with Tracks  42
Target 1800 was Associated with Tracks  73
Target 1813 was Associated with Tracks  3
Target 1895 was Associated with Tracks  56
Target 1940 was Associated with Tracks  17, 66
Target 2059 was Associated with Tracks  39
Target 2089 was Associated with Tracks  2
Target 2109 was Associated with Tracks  48
Target 2111 was Associated with Tracks  15
Target 2127 was Associated with Tracks  36
Target 2133 was Associated with Tracks  1
Target 2142 was Associated with Tracks  49
Target 2373 was Associated with Tracks  4
Target 2438 was Associated with Tracks  60
Target 2494 was Associated with Tracks  19
Target 2805 was Associated with Tracks  14
Target 2810 was Associated with Tracks  25
Target 2891 was Associated with Tracks  27, 80, 81, 82, 86, 91, 93, 95, 100, 108
Target 2900 was Associated with Tracks  20, 53
Target 2931 was Associated with Tracks  58
Target 3019 was Associated with Tracks  7, 106
Target 3050 was Associated with Tracks  99, 110
Target 3051 was Associated with Tracks  34
Target 3089 was Associated with Tracks  68, 72, 76, 78, 84, 88
Target 3255 was Associated with Tracks  21, 70, 105
Target 3478 was Associated with Tracks  6
Target 3482 was Associated with Tracks  43, 79
Target 3501 was Associated with Tracks  26, 104
Target 3812 was Associated with Tracks  77, 89
Target 3877 was Associated with Tracks  75
Target 3887 was Associated with Tracks  18
```

Figure 142

TRACK DATA MENU: *Option 7*

PLOT Track Covariances Submenu: *Option 1*

```
Track Data MENU 2:
  0.  PLOT Tracks
  1.  Output Tables by Track Numbers containing Number of Associated Detections and:
      a.  Minimum time and Maximum time
      b.  Range of Track Coordinates
  2.  PLOT One Track
  3.  PLOT One Track and Associated Detections
  4.  PLOT Association Cost
  5.  COMPUTE TABULAR Summary of Innovation (Detections - Track) along with corresponding plot.
  6.  OUTPUT a Table of Target ID vs. Associated Tracks
  7.  PLOT Track Covariances vs. Time
  8.  PLOT Covariance Ellipses for Detections vs. Tracks
  9.  PRINT OUT (by time tick) Selected Data Corresponding to a Particular Track
 10.  PLOT ALL Track Points Corresponding to a Particular Target ID
 11.  PLOT Velocity by Track
 12.  TRANSFER to Scan Data Menu
 13.  QUIT
MENU Choice:  7
```

Figure 143

```
**************************************************
INPUT Track Number to be Viewed:  5
**************************************************
```

Figure 144

```
PLOT Track Covariances Submenu:
  1.  DISREGARD 'Interaction' Covariances and PLOT Variances - [6 values]
  2.  DISREGARD 'Interaction' Covariances and PLOT Standard Deviations - [3 values ONLY]
  3.  'DIAGONALIZE' Variances by Utilizing Interaction Covariances and Plot Variances - [3 values]
  4.  'DIAGONALIZE' Variances by Utilizing Interaction Covariances and Plot Standard Deviations - [3 values]
PLOT Track Covariances Submenu Choice:  1
```

Figure 145

Option 7, **PLOT Track Covariances vs. Time** is the next *Option* to be illustrated. **Four** Track Covariance Submenu Choices are currently available (**Figure 145**). A theoretical discussion of these *Options* might be helpful to the User and will be provided in the future. [The construction of the Covariance "Error Ellipses" also will be elaborated upon in this discussion.]

For this interim document, an example using Track 5 will be used for both **Track Data Menu** *Option 7* as well as *Option 8*.

TRACK DATA MENU: *Option 7* Continued

PLOT Track Covariances Submenu: *Option 1* Continued

Figure 146 below is XGobi's "Variable Panel" when the response to the PLOT Track Covariances Submenu (**Figure 145** on page A-100) is

1. DISREGARD 'Interaction' Covariances and PLOT Variances - [6 values]

All plots for Track 5 differ from each other and are included below for completeness and for the User's perusal in determining the usefulness of the various plots for his/her analysis purposes.

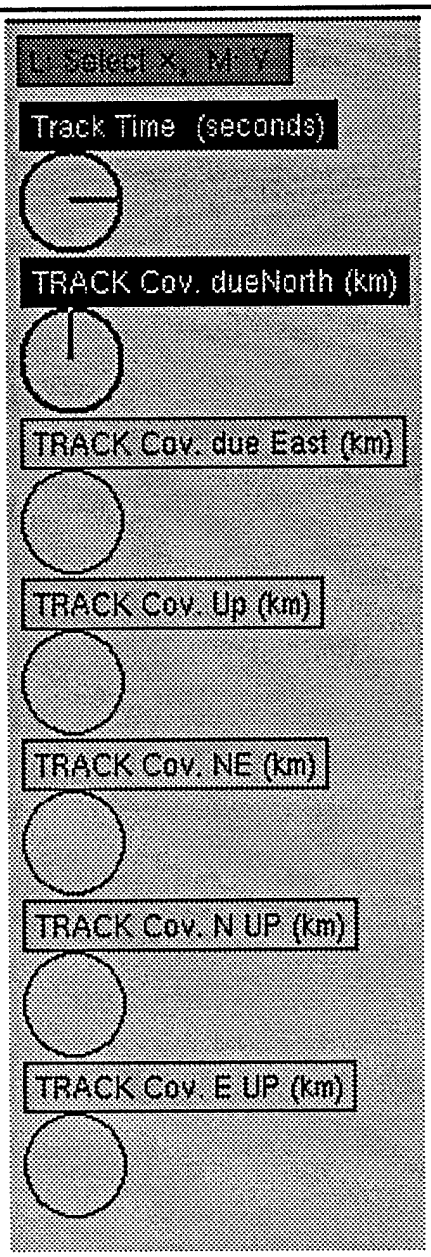


Figure 146

TRACK DATA MENU: *Option 7* Continued

PLOT Track Covariances Submenu: *Option 1* Continued

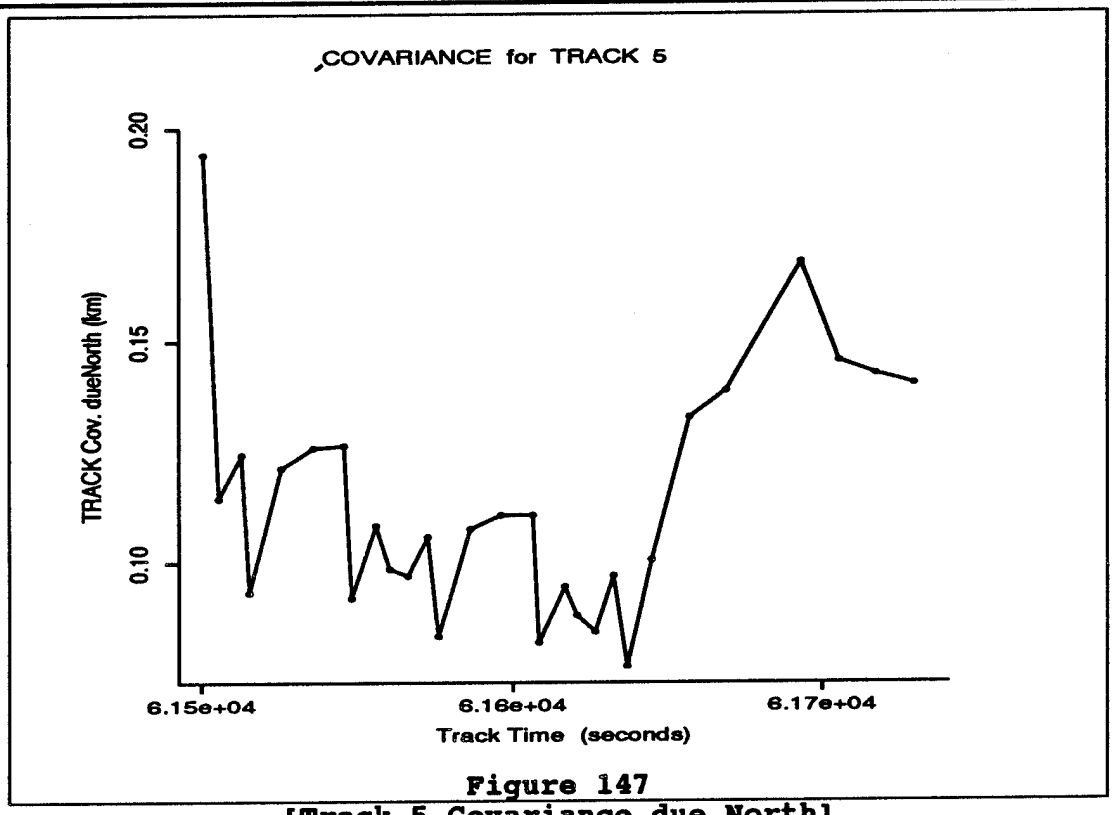


Figure 147
[Track 5 Covariance due North]

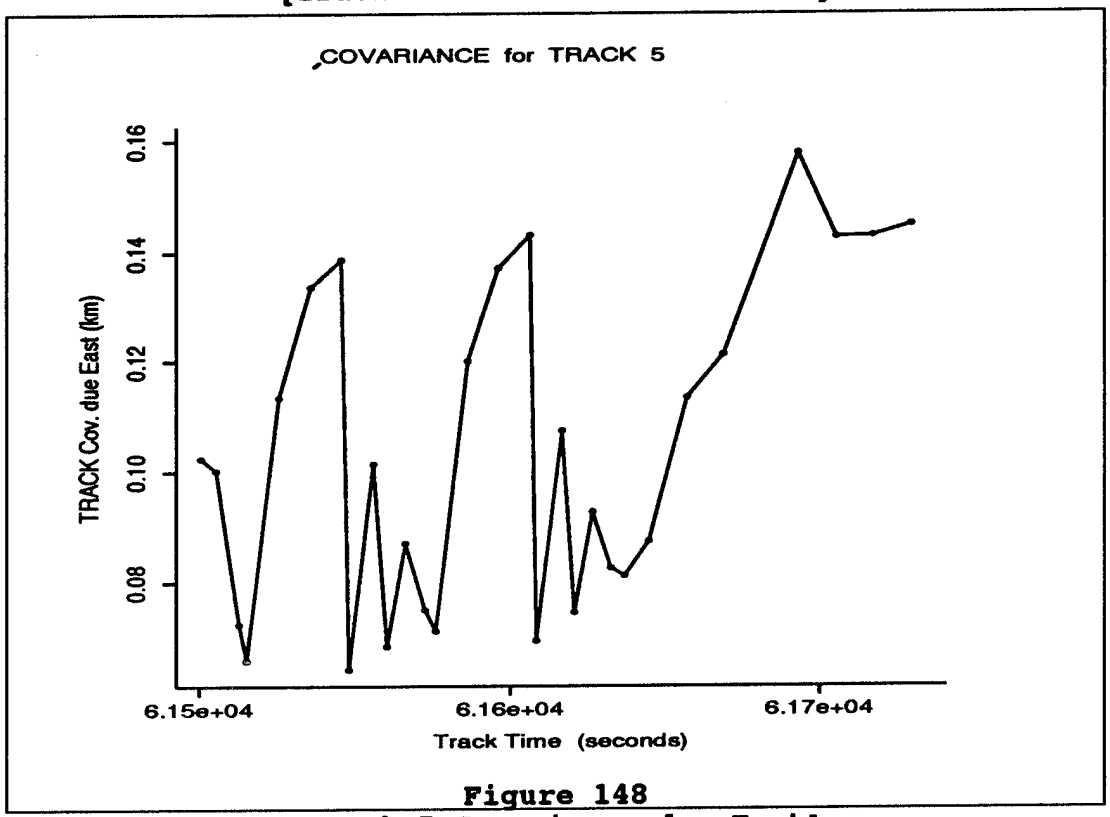


Figure 148
[Track 5 Covariance due East]

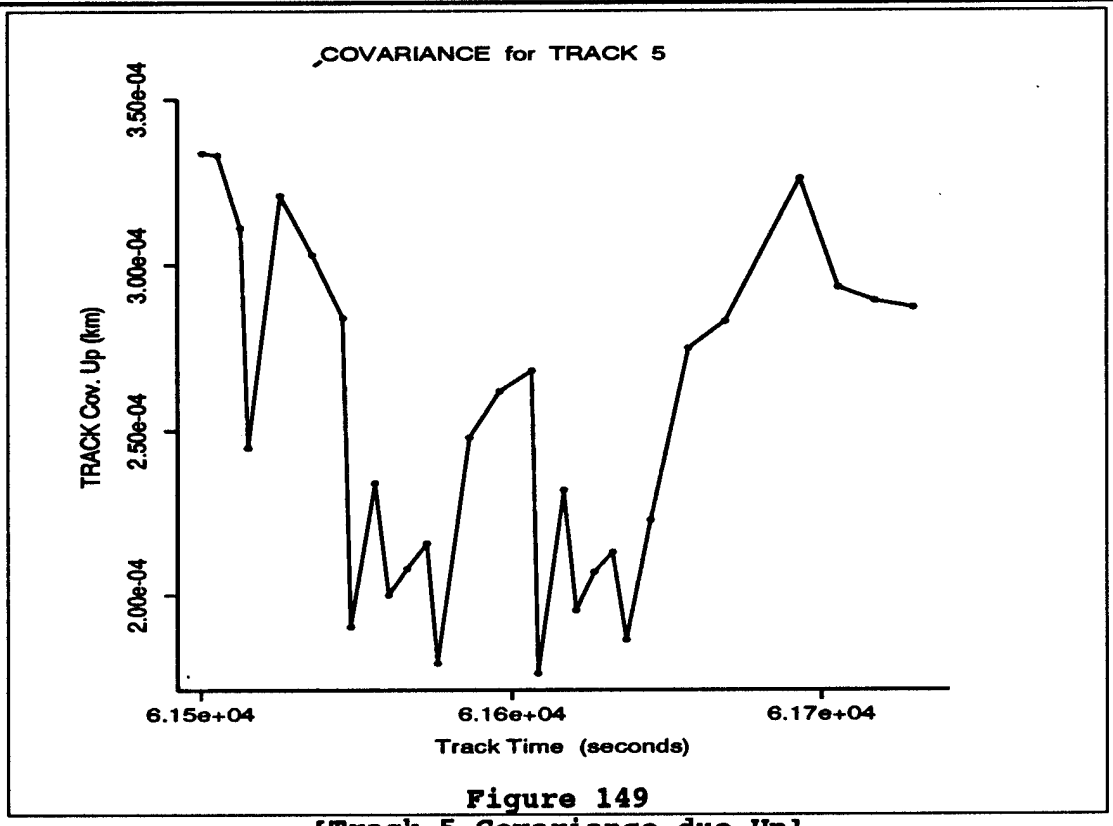


Figure 149
[Track 5 Covariance due Up]

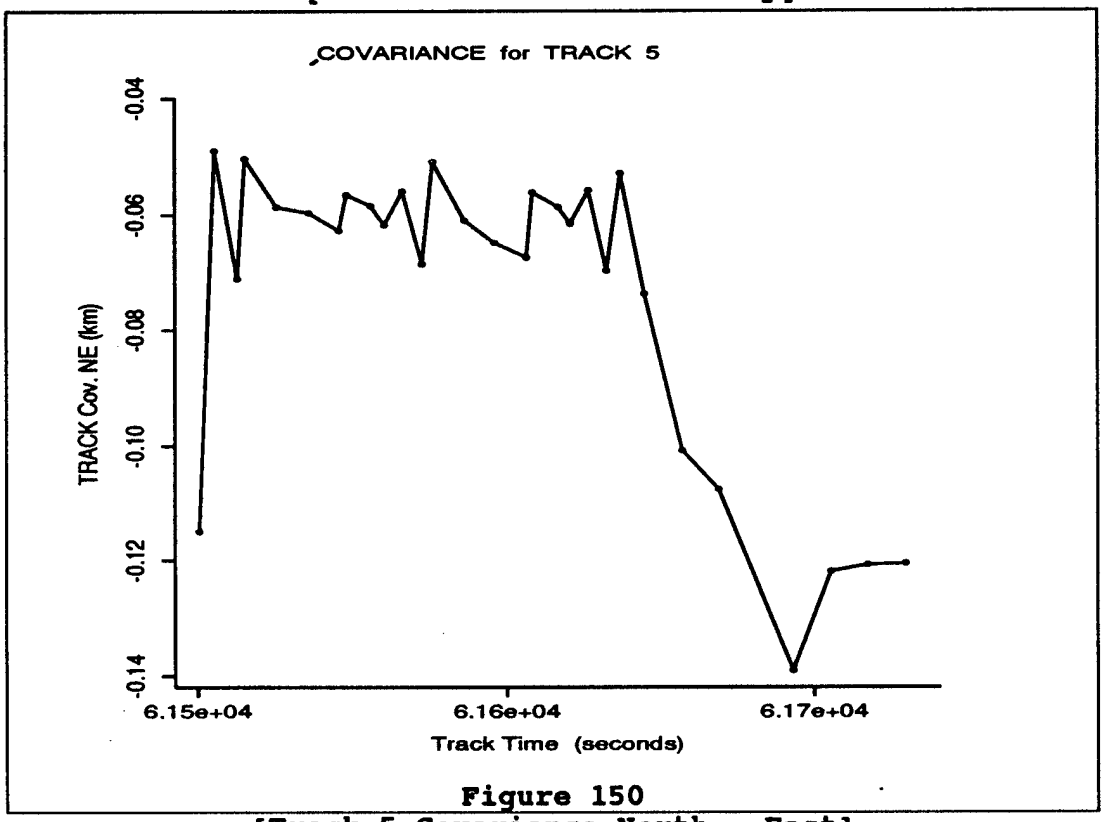


Figure 150
[Track 5 Covariance North - East]

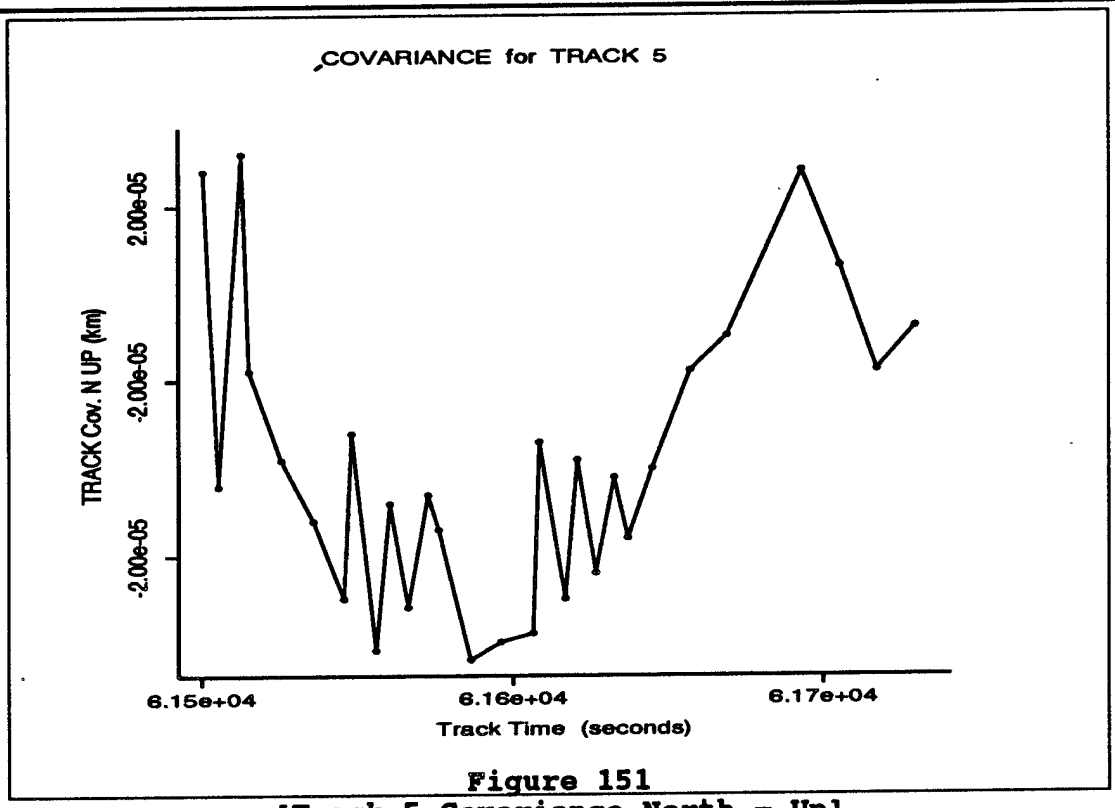


Figure 151
[Track 5 Covariance North - Up]

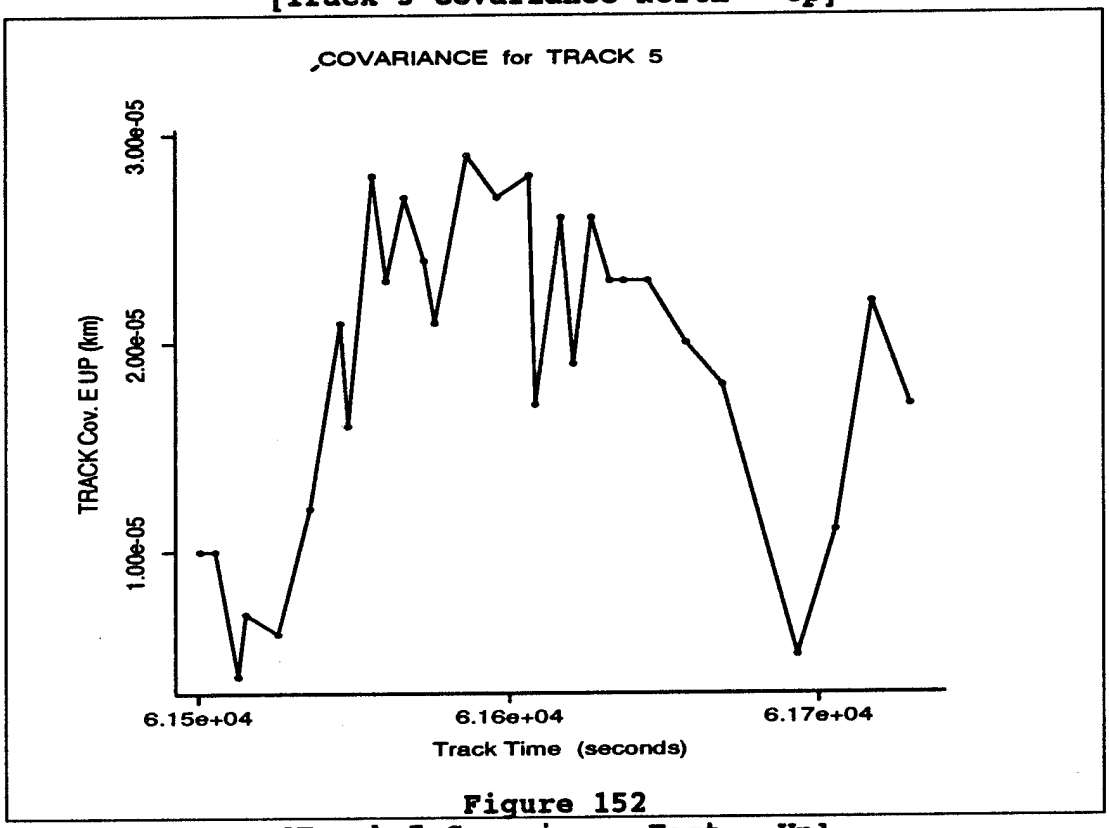


Figure 152
[Track 5 Covariance East - Up]

TRACK DATA MENU: *Option 7* Continued

PLOT Track Covariances Submenu: *Option 2*

```
PLOT Track Covariances Submenu:
  1. DISREGARD 'Interaction' Covariances and PLOT Variances - [6 values]
  2. DISREGARD 'Interaction' Covariances and PLOT Standard Deviations - [3 values ONLY]
  3. 'DIAGONALIZE' Variances by Utilizing Interaction Covariances and Plot Variances - [3 values]
  4. 'DIAGONALIZE' Variances by Utilizing Interaction Covariances and Plot Standard Deviations - [3 values]
PLOT Track Covariances Submenu Choice: 2
```

Figure 153

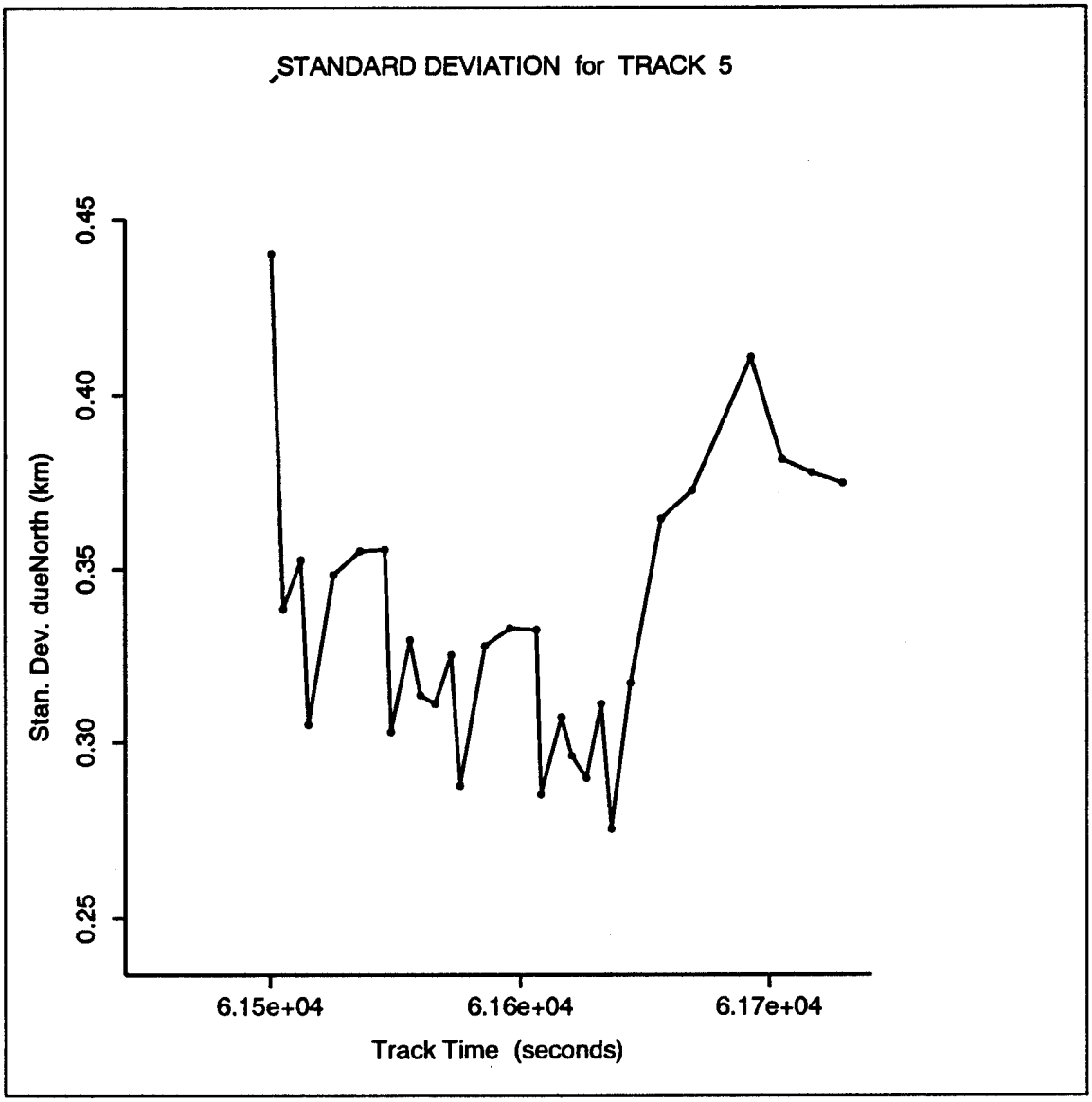


Figure 154
[Track 5 Standard Deviation due North]

TRACK DATA MENU: *Option 7* Continued

PLOT Track Covariances Submenu: *Option 2* Continued

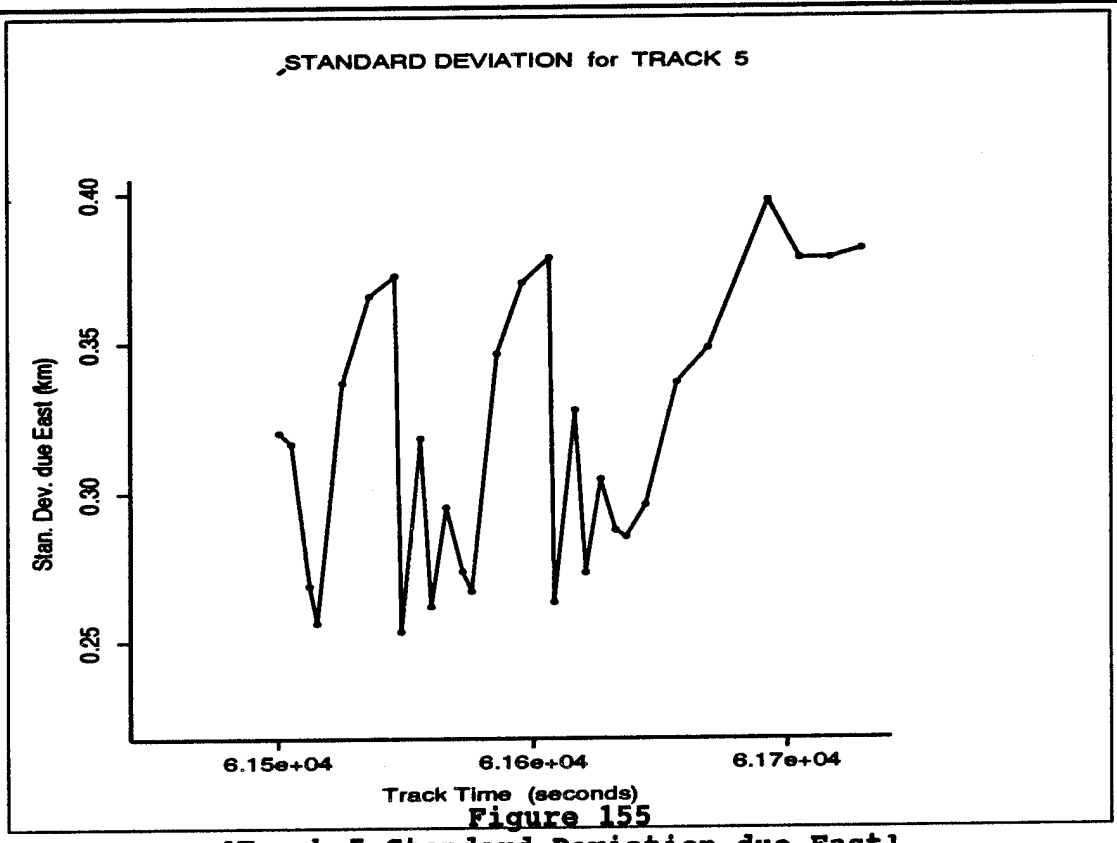


Figure 155

[Track 5 Standard Deviation due East]

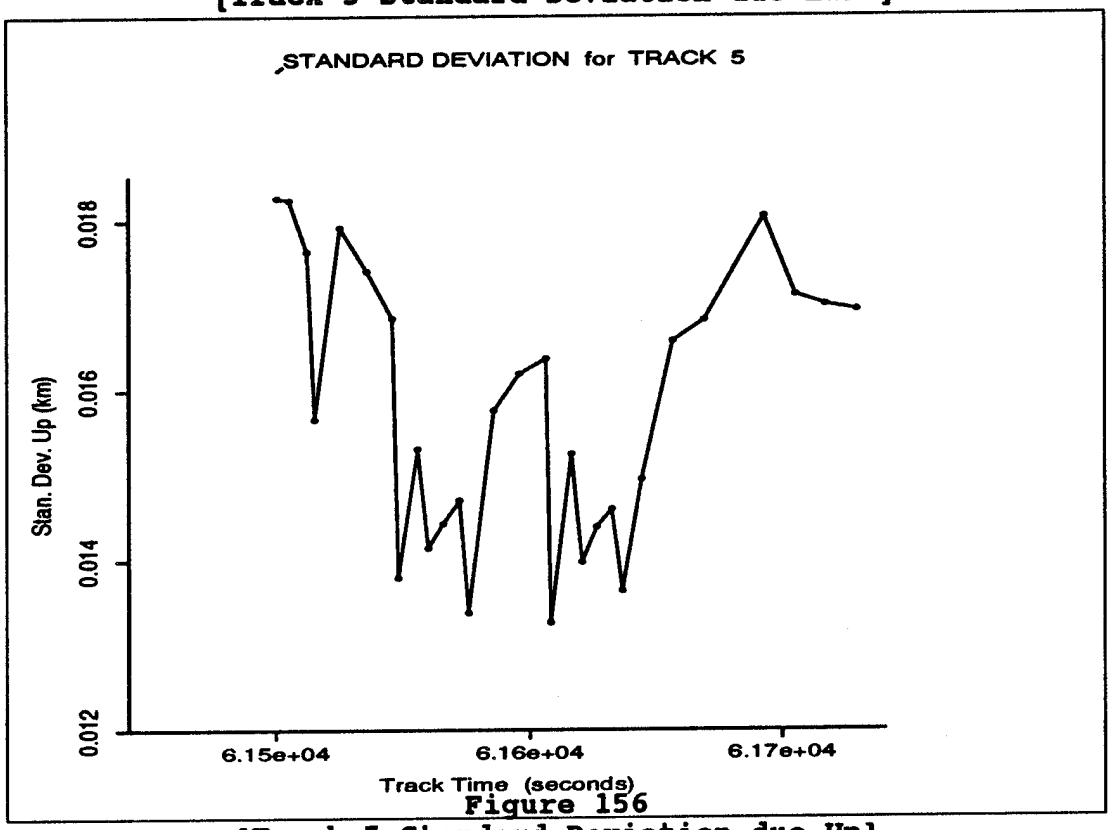


Figure 156

[Track 5 Standard Deviation due Up]

TRACK DATA MENU: *Option 7* Continued

PLOT Track Covariances Submenu: *Option 3*

```
PLOT Track Covariances Submenu:
  1. DISREGARD 'Interaction' Covariances and PLOT Variances - [6 values]
  2. DISREGARD 'Interaction' Covariances and PLOT Standard Deviations - [3 values ONLY]
  3. 'DIAGONALIZE' Variances by Utilizing Interaction Covariances and Plot Variances - [3 values]
  4. 'DIAGONALIZE' Variances by Utilizing Interaction Covariances and Plot Standard Deviations - [3 values]
PLOT Track Covariances Submenu Choice: 3
```

Figure 157

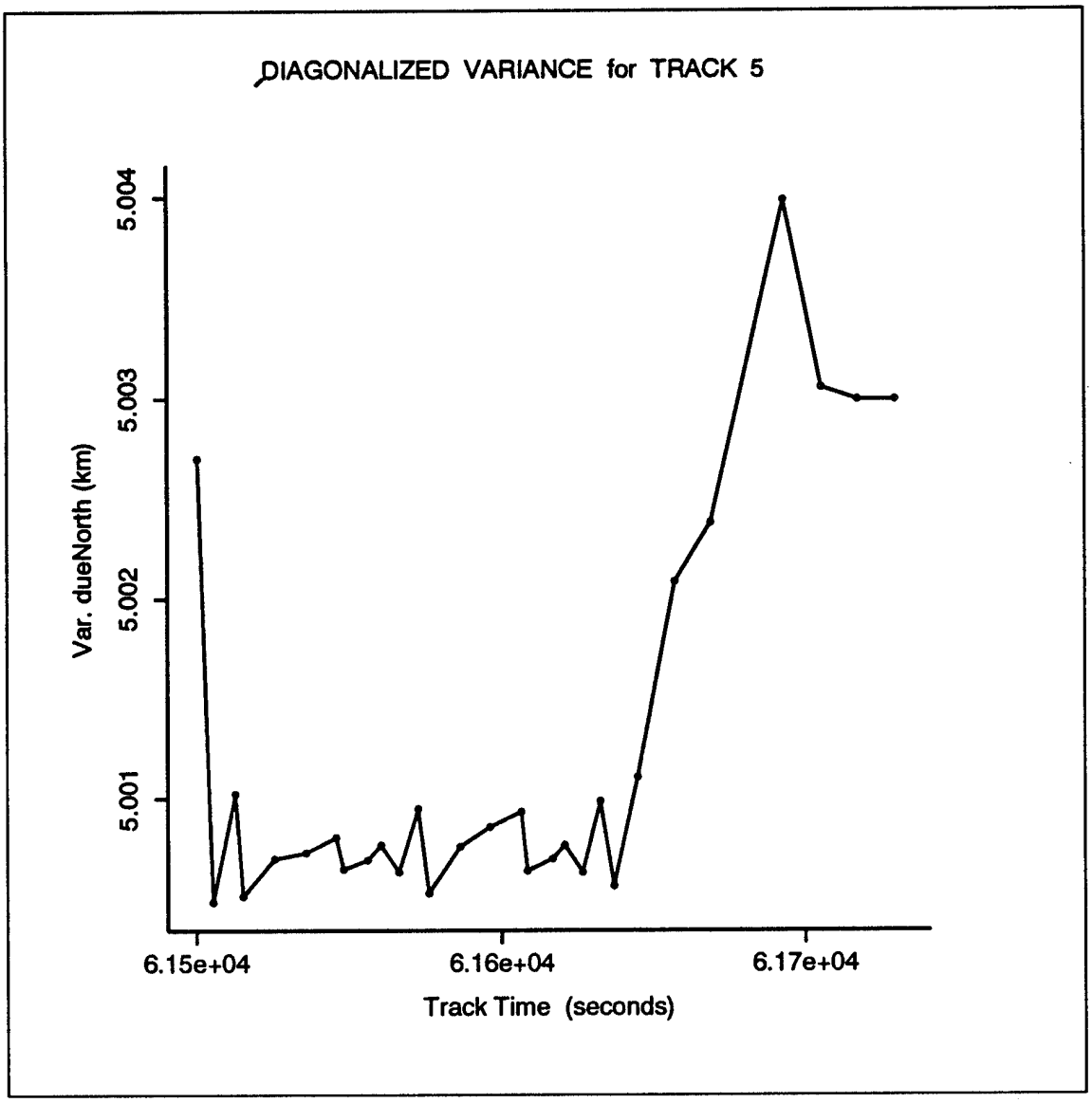


Figure 158
[Track 5 DIAGONALIZED Variance due North]

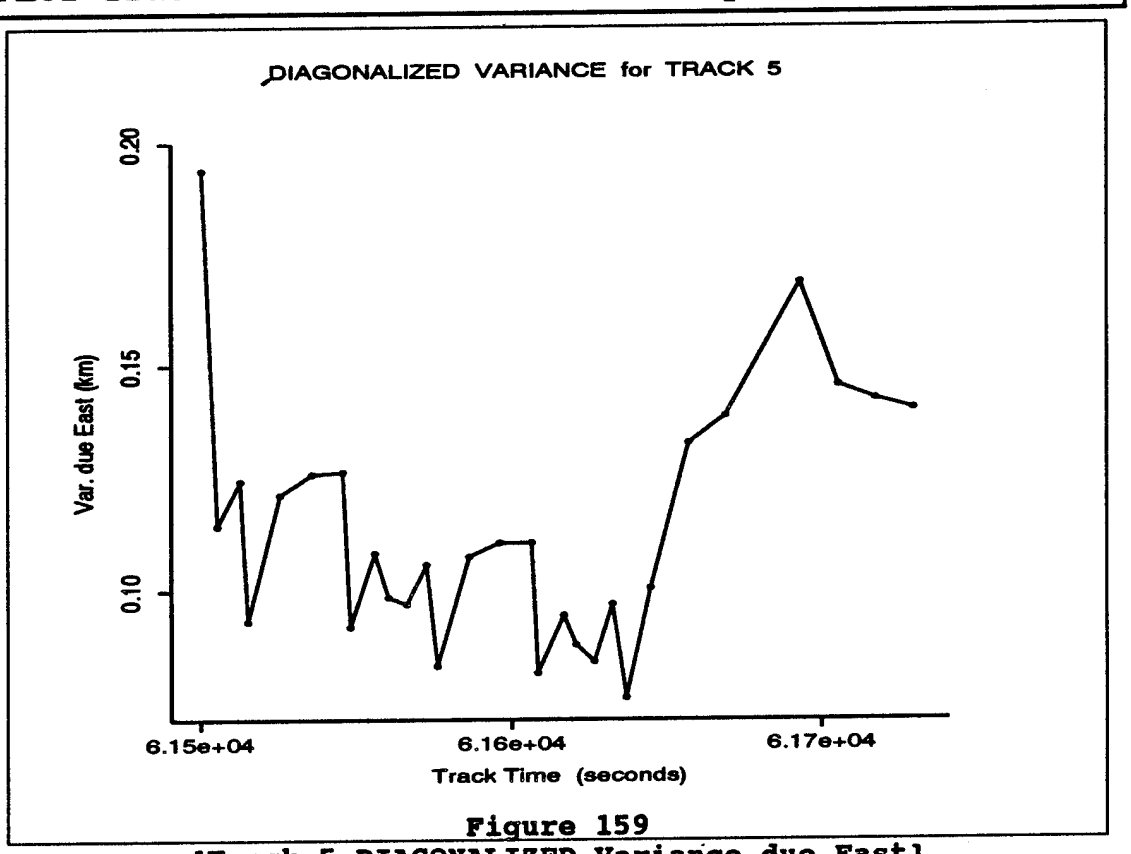


Figure 159
[Track 5 DIAGONALIZED Variance due East]

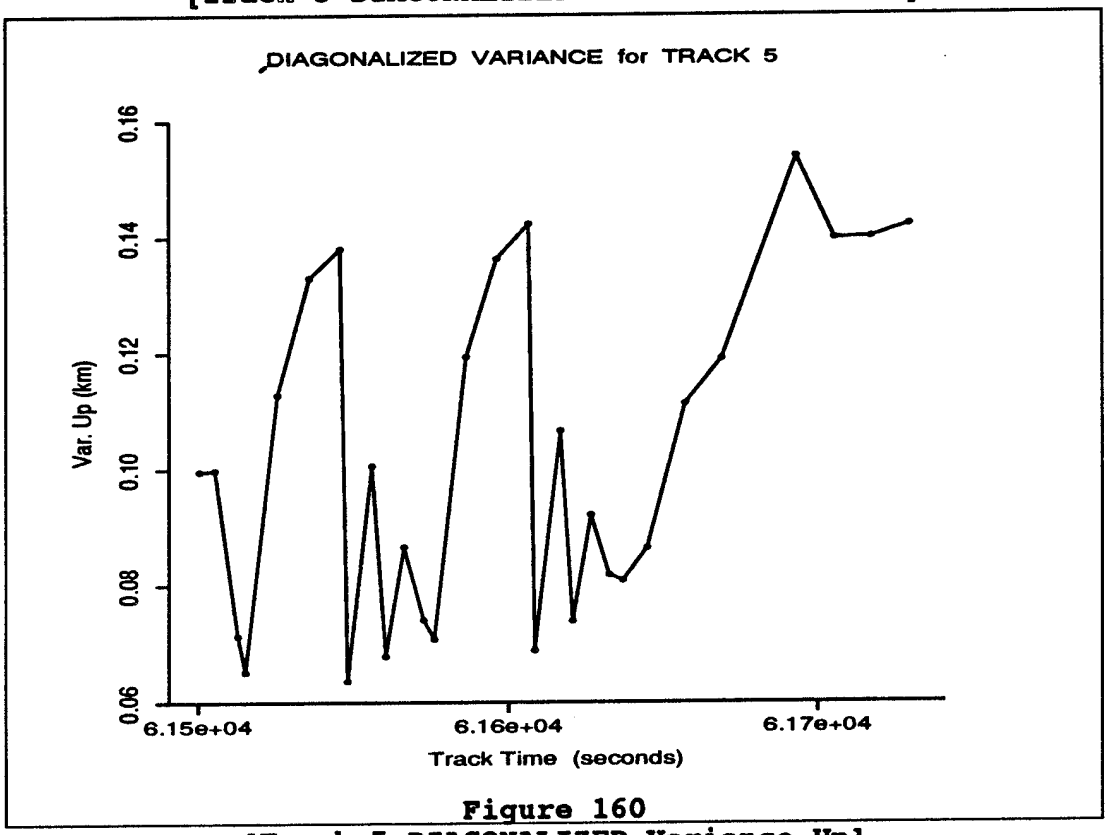


Figure 160
[Track 5 DIAGONALIZED Variance Up]

TRACK DATA MENU: *Option 7* Continued

PLOT Track Covariances Submenu: *Option 4*

```
PLOT Track Covariances Submenu:
  1. DISREGARD 'Interaction' Covariances and PLOT Variances - [6 values]
  2. DISREGARD 'Interaction' Covariances and PLOT Standard Deviations - [3 values ONLY]
  3. 'DIAGONALIZE' Variances by Utilizing Interaction Covariances and Plot Variances - [3 values]
  4. 'DIAGONALIZE' Variances by Utilizing Interaction Covariances and Plot Standard Deviations - [3 values]
PLOT Track Covariances Submenu Choice: 4
```

Figure 161

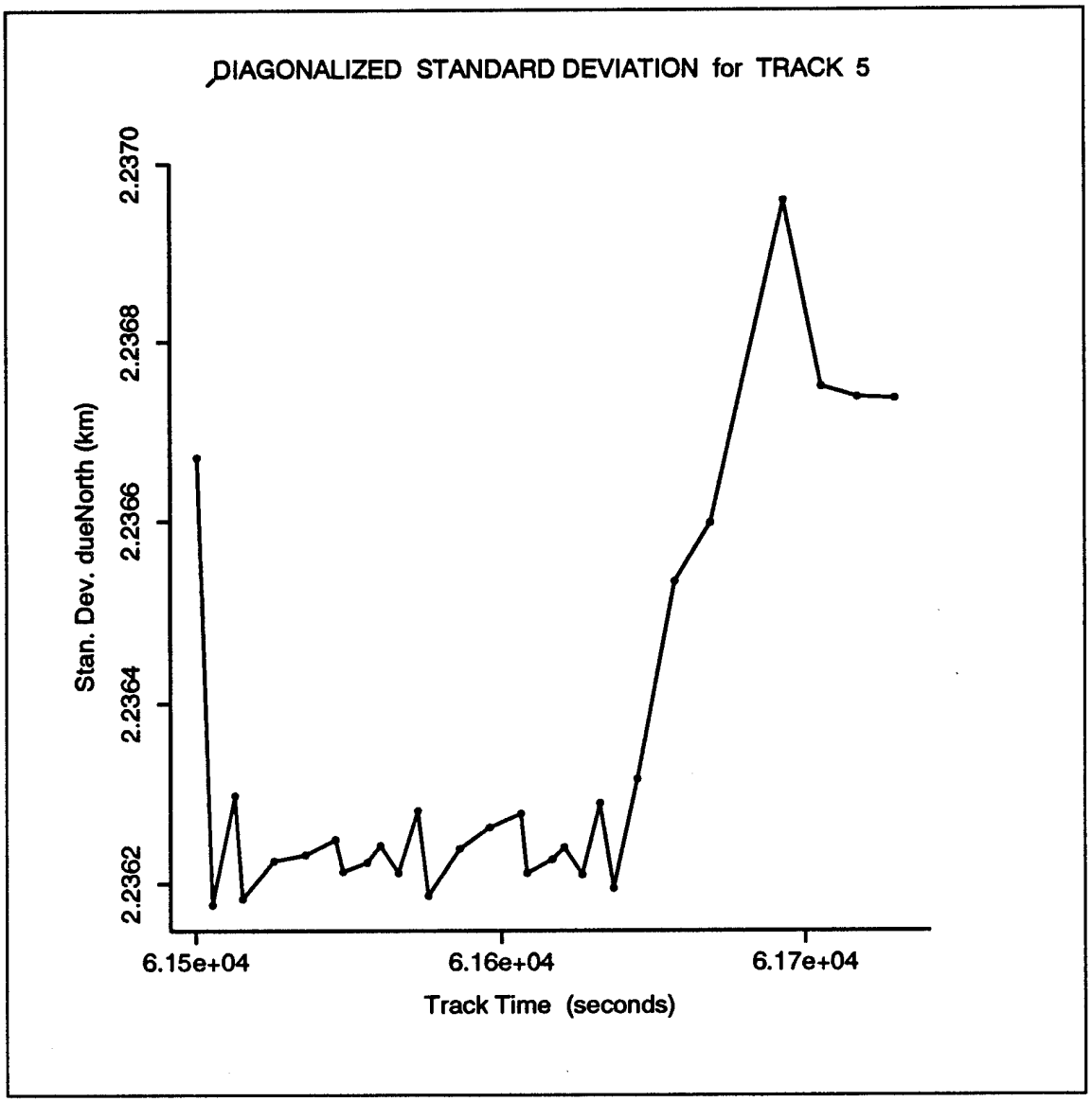


Figure 162
[Track 5 DIAGONALIZED Standard Deviation due North]

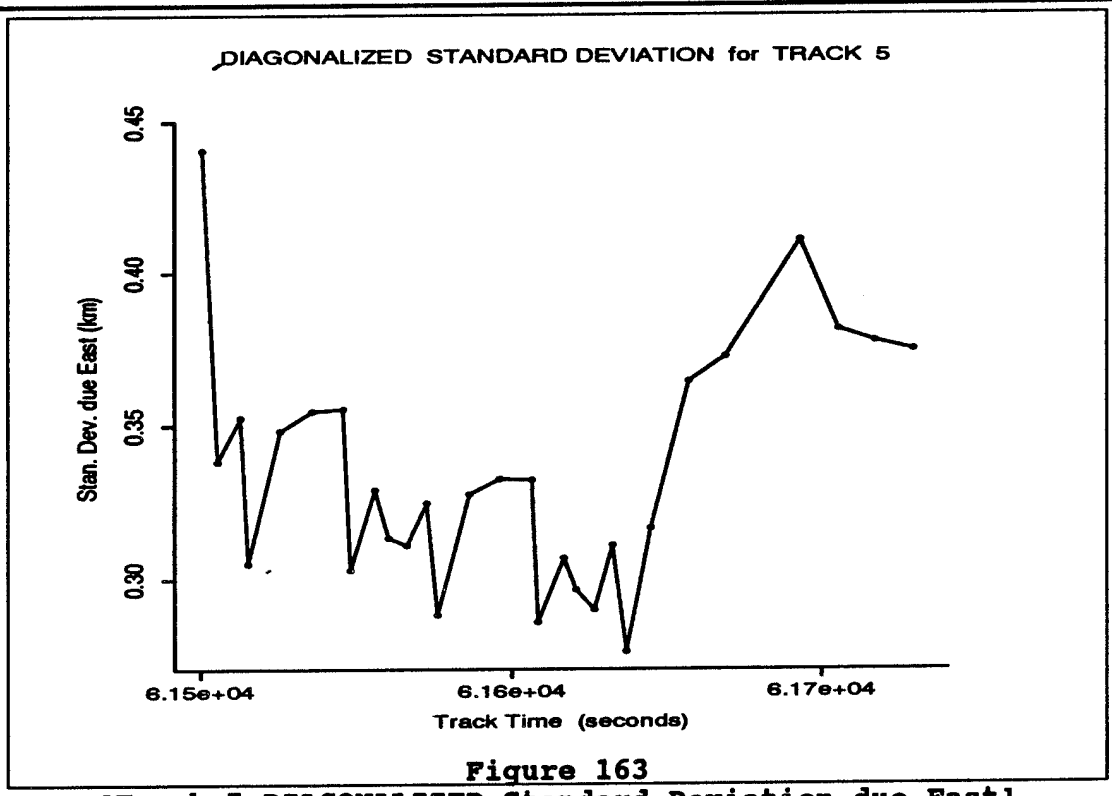


Figure 163

[Track 5 DIAGONALIZED Standard Deviation due East]

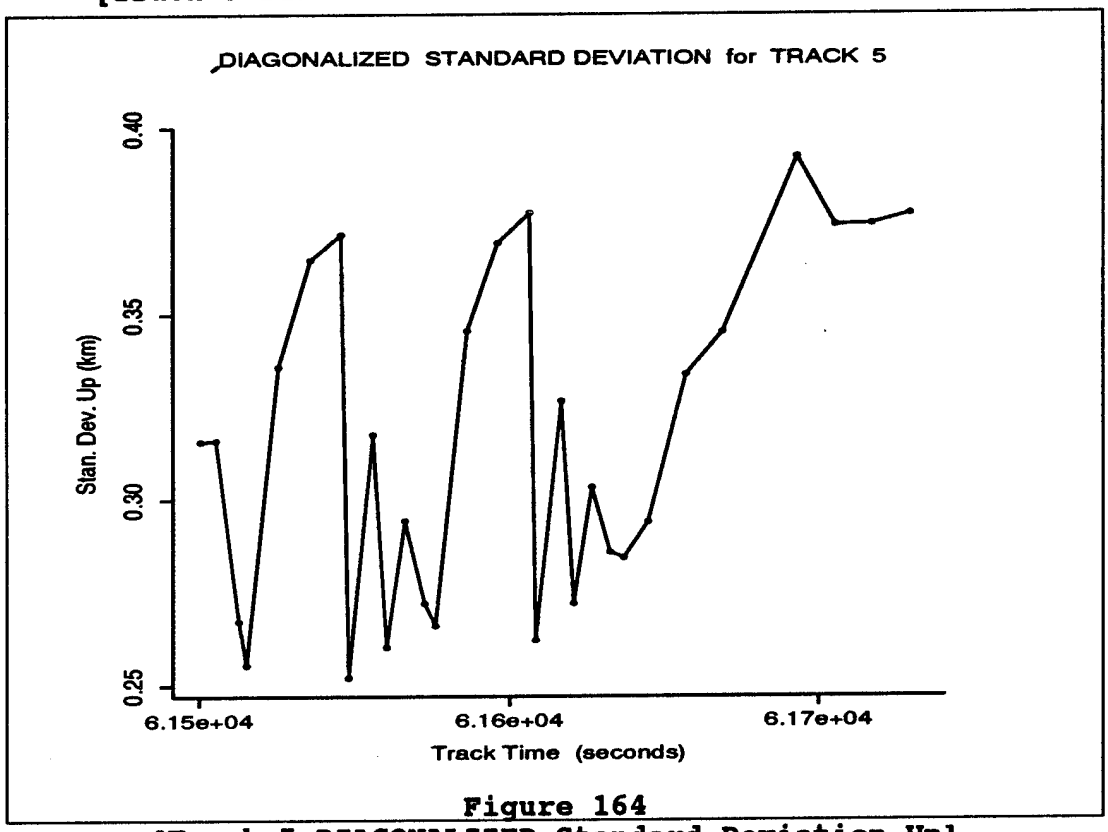


Figure 164

[Track 5 DIAGONALIZED Standard Deviation Up]

TRACK DATA MENU: *Option 8*

```
Track Data MENU 2:
  0.  PLOT Tracks
  1.  Output Tables by Track Numbers containing Number of Associated Detections and:
      a.  Minimum time and Maximum time
      b.  Range of Track Coordinates
  2.  PLOT One Track
  3.  PLOT One Track and Associated Detections
  4.  PLOT Association Cost
  5.  COMPUTE TABULAR Summary of Innovation (Detections - Track) along with corresponding plot.
  6.  OUTPUT a Table of Target ID vs. Associated Tracks
  7.  PLOT Track Covariances vs. Time
  8.  PLOT Covariance Ellipses for Detections vs. Tracks
  9.  PRINT OUT (by time tick) Selected Data Corresponding to a Particular Track
 10.  PLOT ALL Track Points Corresponding to a Particular Target ID
 11.  PLOT Velocity by Track
 12.  TRANSFER to Scan Data Menu
 13.  QUIT
MENU Choice:  8
```

Figure 165

```
**************************************************
INPUT Track Number to be Viewed:  5
**************************************************
```

Figure 166

```
SENSOR Display Submenu:
  1.  PLOT Location of Dansville ONLY
  2.  PLOT Location of Remsen ONLY
  3.  PLOT Locations of ALL Sensors
  4.  DO NOT PLOT Location of Any Sensor

SENSOR Display Submenu Choice:  3
```

Figure 167

Option 8 results in a plot of Covariance "Innovation" Ellipses centered around each Track point. The following plots result from the invocation of this *Option* and subsequent inputs listed above:

- **Figure 168** - Initial plot with Sensor Locations
- **Figure 169** - Subset data menu used to eliminate plotting of Sensor locations
- **Figure 170** - Plot which results from this subsetting
- **Figure 171** - Longitude-Altitude Covariance Ellipses (**with** Sensors)
- **Figure 172** - Longitude-Altitude Covariance Ellipses (**without** Sensors)
- **Figure 173** - Latitude-Altitude Covariance Ellipse (**with** Sensors)
- **Figure 174** - Latitude-Altitude Covariance Ellipse (**without** Sensors)

TRACK DATA MENU: *Option 8* Continued

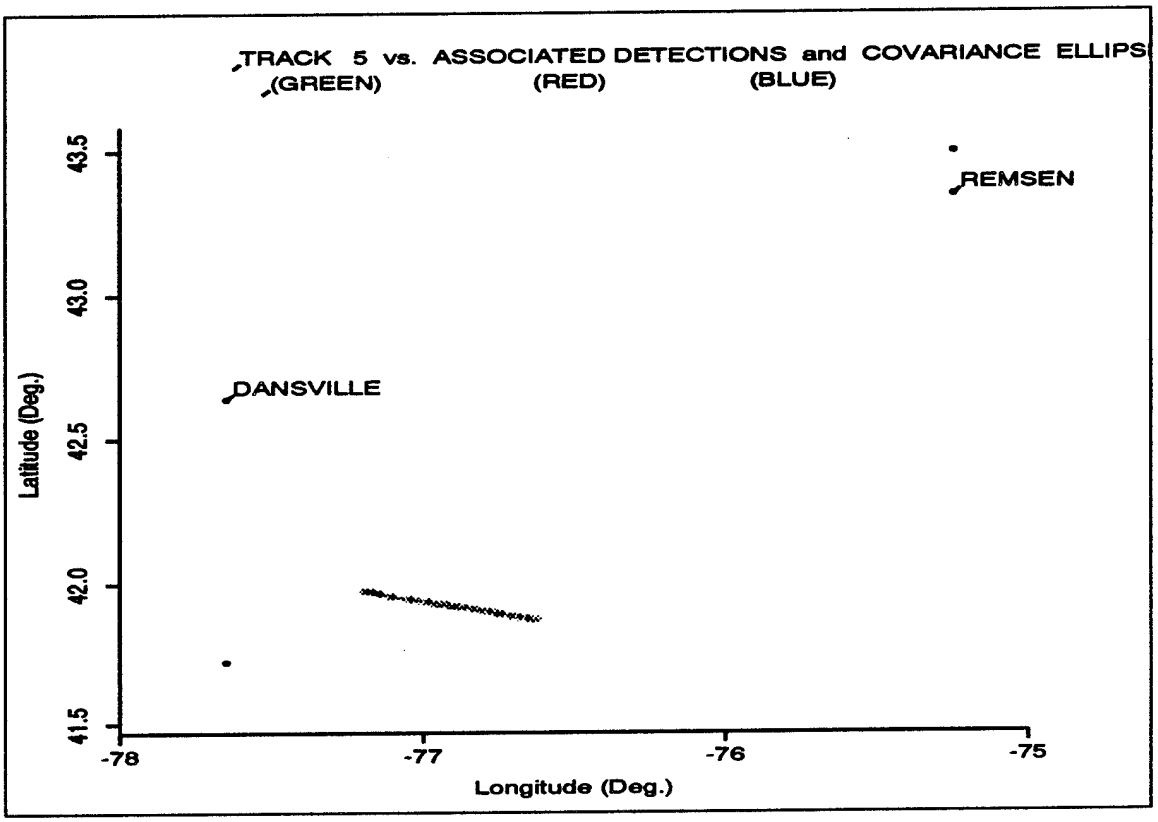


Figure 168
[Initial Plot with Sensor Locations]

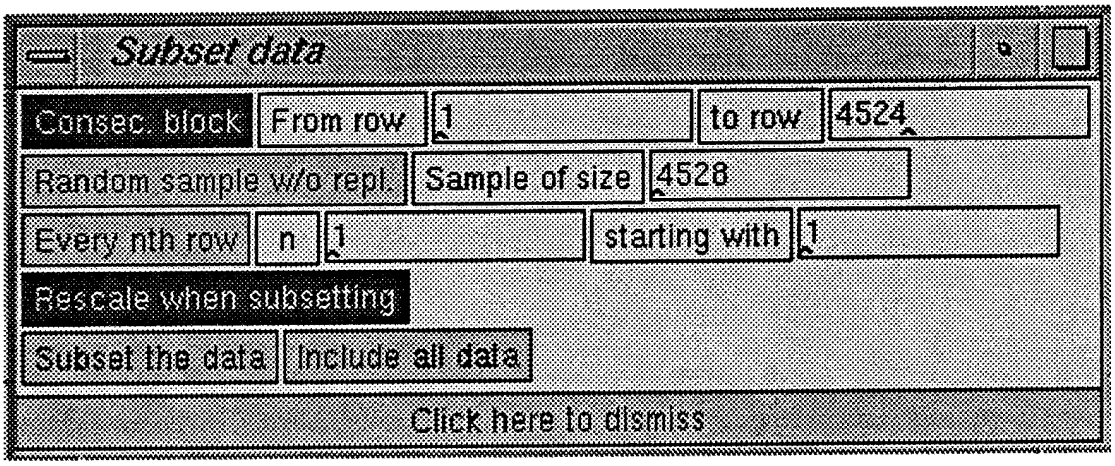


Figure 169
[Subset data menu used to eliminate plotting of Sensor Locations]

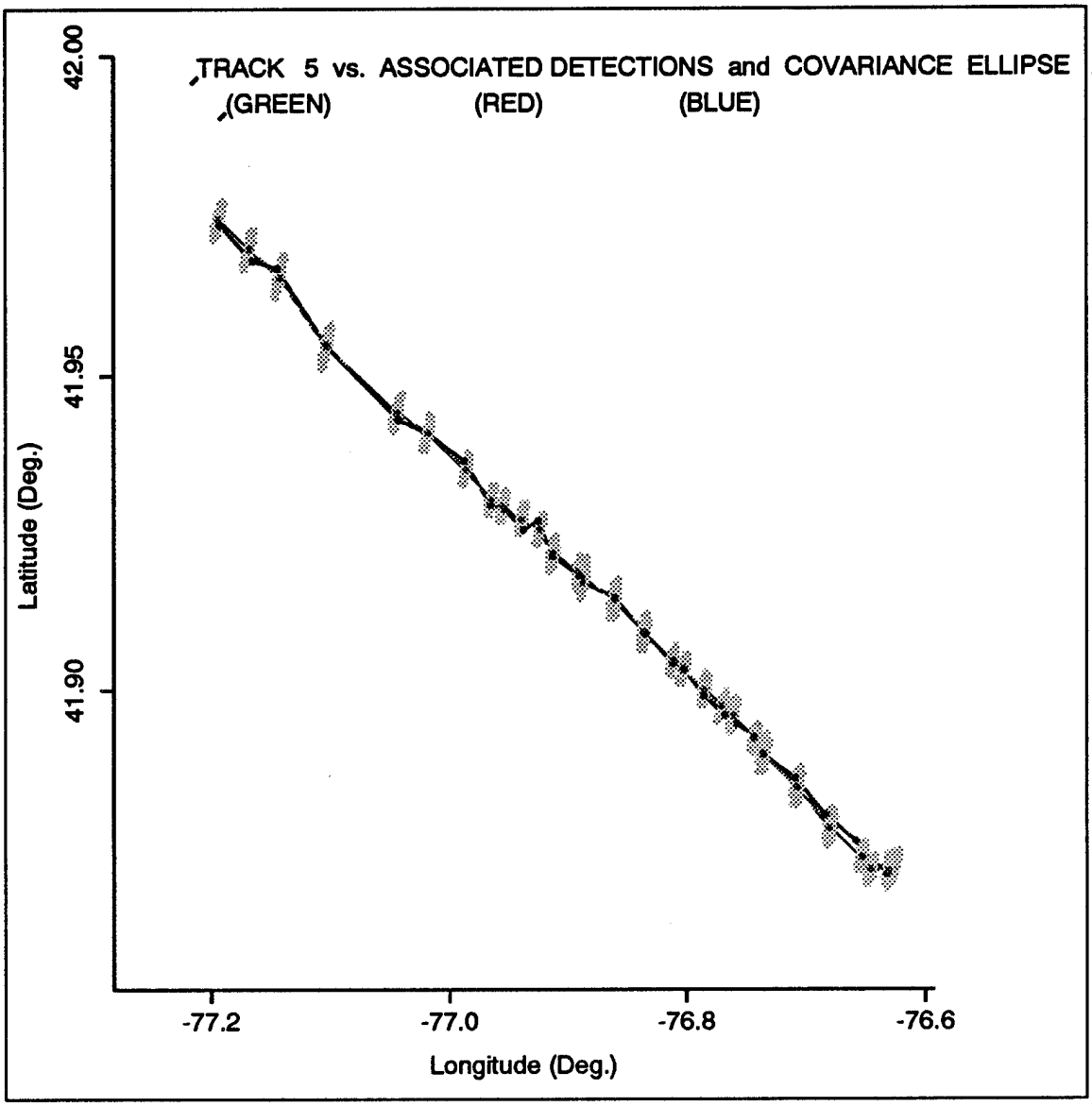


Figure 170
[Longitude-Latitude Plot which results from Sensor Location Removal]

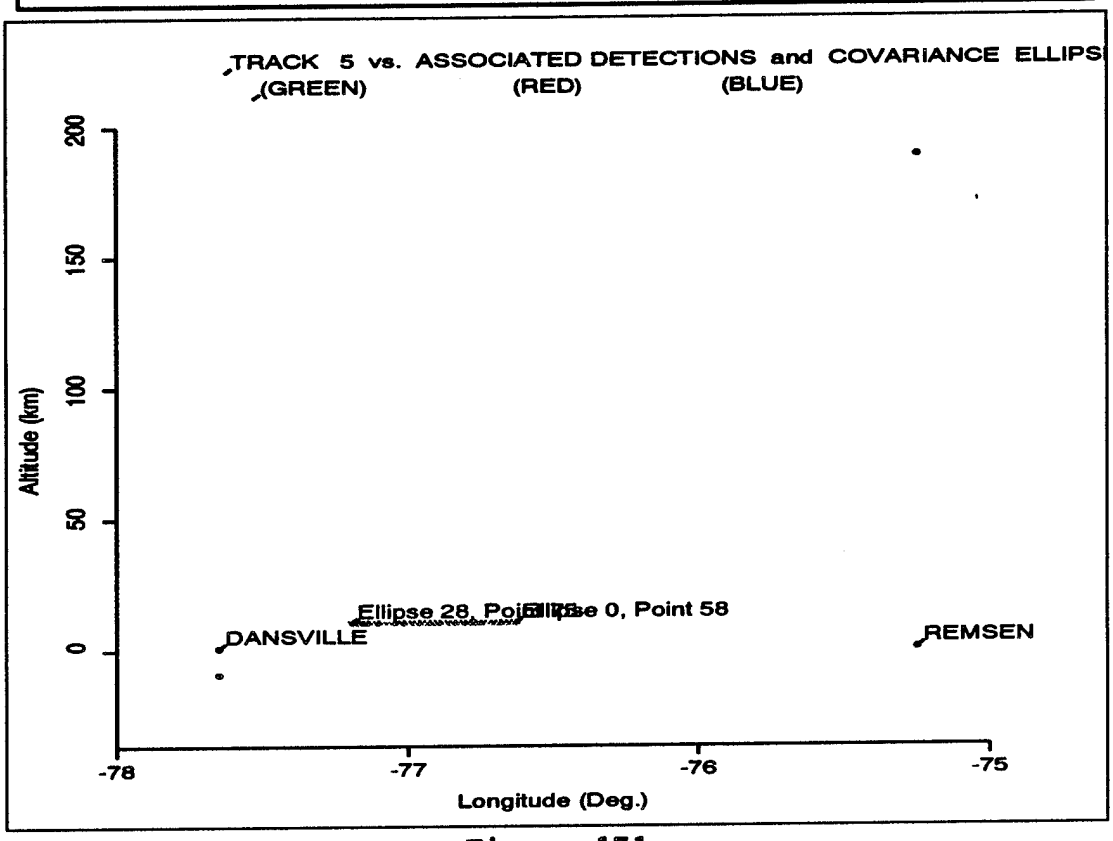


Figure 171
[Longitude-Altitude Covariance Ellipses (<u>with</u> Sensors)]

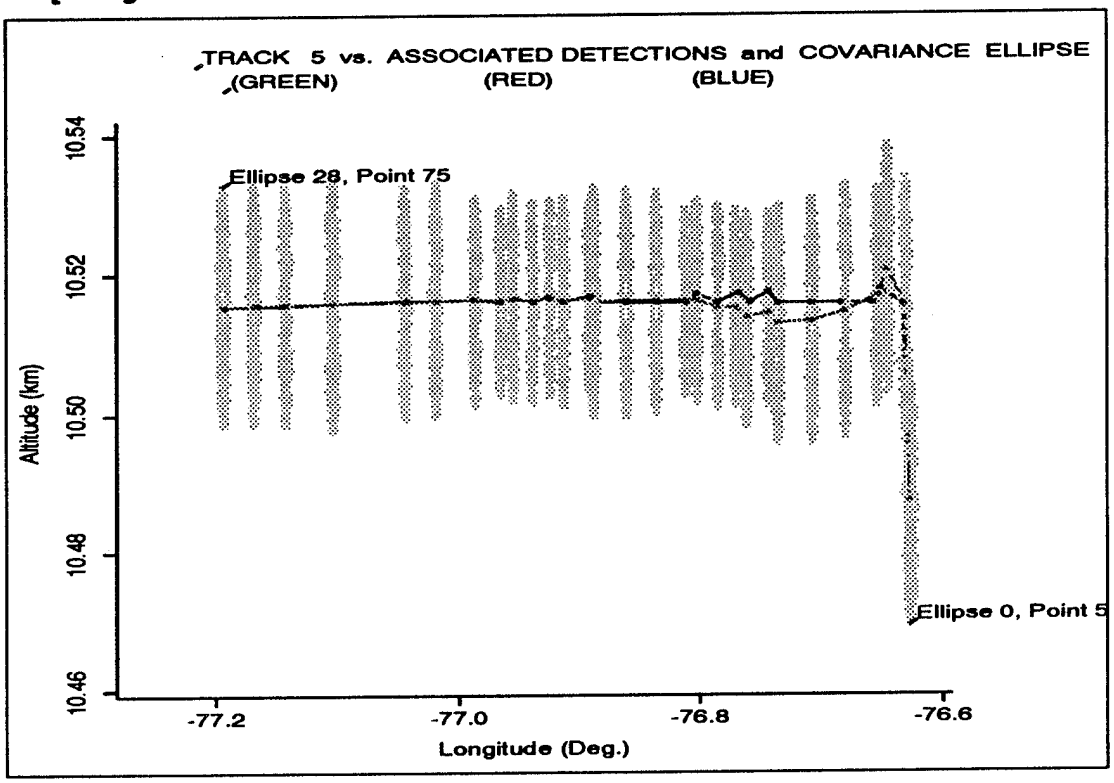


Figure 172
[Longitude-Altitude Covariance Ellipses (<u>without</u> Sensors)]

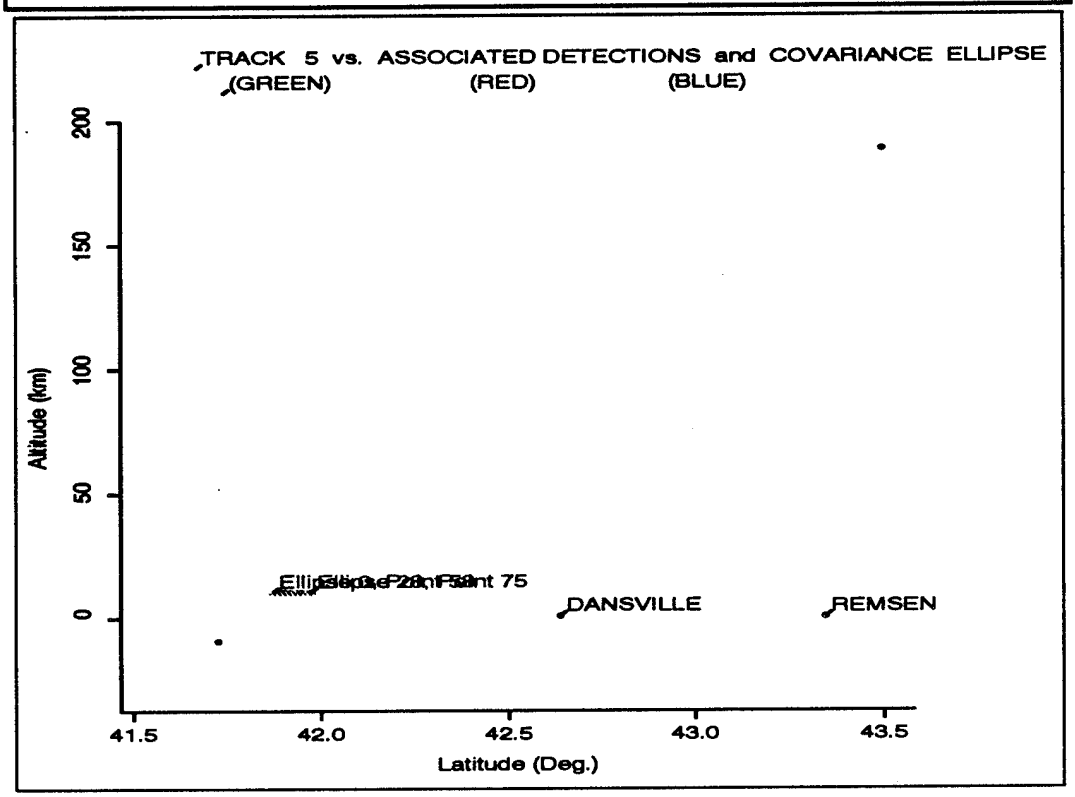


Figure 173
[Latitude-Altitude Covariance Ellipses (<u>with</u> Sensors)]

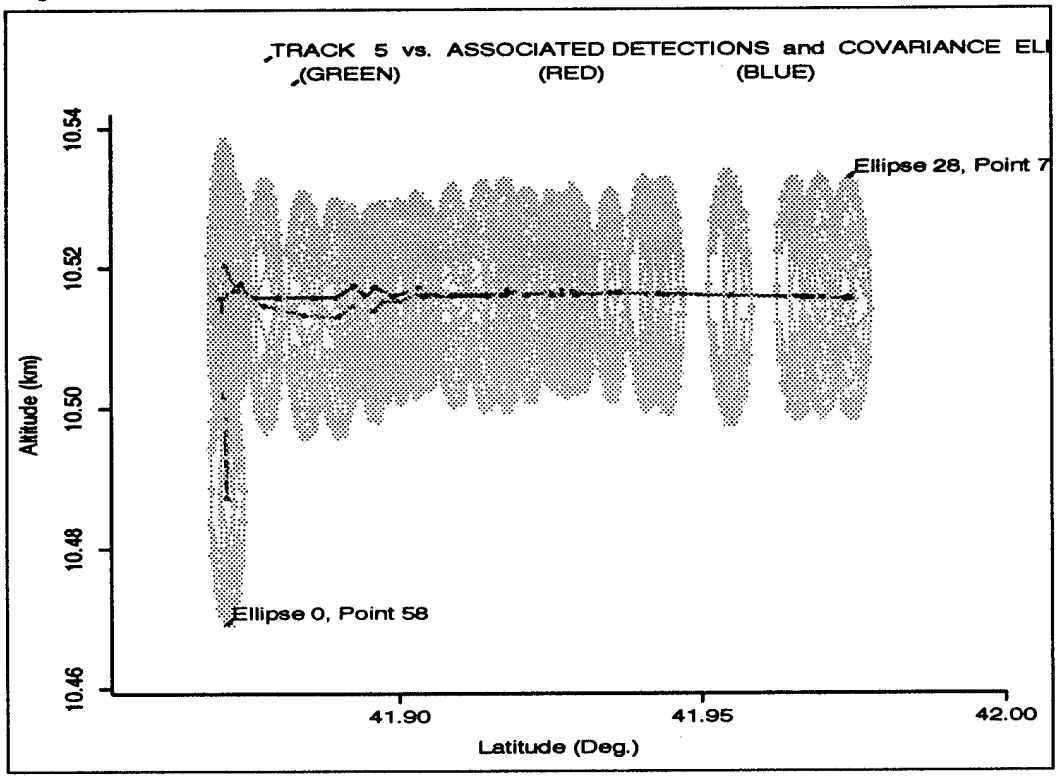


Figure 174
[Latitude-Altitude Covariance Ellipses (<u>without</u> Sensors)]

TRACK DATA MENU: *Option 9*

```
Track Data MENU 2:
  0.  PLOT Tracks
  1.  Output Tables by Track Numbers containing Number of Associated Detections and:
      a.  Minimum time and Maximum time
      b.  Range of Track Coordinates
  2.  PLOT One Track
  3.  PLOT One Track and Associated Detections
  4.  PLOT Association Cost
  5.  COMPUTE TABULAR Summary of Innovation (Detections - Track) along with corresponding plot.
  6.  OUTPUT a Table of Target ID vs. Associated Tracks
  7.  PLOT Track Covariances vs. Time
  8.  PLOT Covariance Ellipses for Detections vs. Tracks
  9.  PRINT OUT (by time tick) Selected Data Corresponding to a Particular Track
 10.  PLOT ALL Track Points Corresponding to a Particular Target ID
 11.  PLOT Velocity by Track
 12.  TRANSFER to Scan Data Menu
 13.  QUIT
MENU Choice:  9
```

Figure 175

```
**************************************************
INPUT Track Number to be Viewed:  5
**************************************************
```

Figure 176

Option 9 allows the User to observe the ASCII data generated by a particular Algorithm. The User is given a list of the Computed Data Set Column HEADINGS and then asked to choose from these variables. The User should then INPUT the numbers corresponding to the variables he/she would like to examine and TERMINATE the entry of these numbers with a "-1" (**Figure 177** on the next page). Currently, the data chosen by the User is written to a file and then the file is immediately spawned to the printer. The file generated by the inputs of **Figure 177** is **Figure 178** on page A-118 or **Figure 178(normalized times)** on page A-119.

TRACK DATA MENU: *Option 9* Continued

```
The COMPUTED Data Set Column HEADINGS ARE:
  1)  Track Number
  2)  Scan Group Number
  3)  Detect # In Scan Group
  4)  LatestAssoc.Detect Long.
  5)  LatestAssoc.Detect Lat.
  6)  LatestAssoc.Detect Alt.
  7)  TRACK Longitude (Deg.)
  8)  TRACK Latitude (Deg.)
  9)  TRACK Altitude (km)
 10)  Vel. Due North (km/s)
 11)  Vel. Due East (km/s)
 12)  Vertical Vel. Up (km/s)
 13)  Velocity Magnitude
 14)  Cost
 15)  Target ID
 16)  TRACK Cov. dueNorth (km)
 17)  TRACK Cov. due East (km)
 18)  TRACK Cov. Up (km)
 19)  TRACK Cov. NE (km)
 20)  TRACK Cov. N UP (km)
 21)  TRACK Cov. E UP (km)
*******************************************************
INPUT the Numbers of the Column HEADINGS to be displayed (one number per line):
        [TERMINATE Data Entry with a -1]
2
3
14
-1
TOTAL Number of Inputs:  3
```

Figure 177

TRACK DATA MENU: *Option 9* Continued

```
          TRACK  5  DATA

   0)  Track Time  (seconds)
   1)  Scan Group Number
   2)  Detect # In Scan Group
   3)  Cost

61500.300781 1.000000 5.000000 0.000000
61505.398438 3.000000 30.000000 -5.780370
61512.601563 4.000000 12.000000 -5.410002
61515.500000 5.000000 33.000000 -8.094408
61525.500000 6.000000 30.000000 -6.182213
61535.800781 8.000000 32.000000 -7.139677
61545.800781 10.000000 38.000000 -7.540648
61548.398438 11.000000 11.000000 -8.967107
61556.101563 12.000000 38.000000 -8.019546
61560.398438 13.000000 10.000000 -8.716254
61566.199219 14.000000 37.000000 -8.791194
61572.601563 15.000000 13.000000 -8.763229
61576.101563 16.000000 33.000000 -9.130766
61586.300781 17.000000 32.000000 -8.152668
61596.300781 19.000000 36.000000 -7.975923
61606.601563 21.000000 39.000000 -7.742529
61608.699219 22.000000 12.000000 -9.047667
61616.800781 23.000000 40.000000 -8.527955
61620.800781 24.000000 11.000000 -8.740450
61626.601563 25.000000 40.000000 -8.737582
61632.800781 26.000000 11.000000 -8.867112
61636.898438 27.000000 43.000000 -9.112901
61644.699219 28.000000 13.000000 -8.510533
61657.000000 32.000000 10.000000 -7.982815
61669.000000 34.000000 10.000000 -7.509470
61693.000000 38.000000 14.000000 -5.057766
61705.101563 41.000000 12.000000 -7.035861
61717.000000 43.000000 11.000000 -6.811563
61729.101563 45.000000 17.000000 -7.502965
```

Figure 178

```
          TRACK  5  DATA

   0)  Track Time  (seconds)
   1)  Scan Group Number
   2)  Detect # In Scan Group
   3)  Cost

0.402344 1.000000 5.000000 0.000000
5.500000 3.000000 30.000000 -5.780370
12.703125 4.000000 12.000000 -5.410002
15.601563 5.000000 33.000000 -8.094408
25.601563 6.000000 30.000000 -6.182213
35.902344 8.000000 32.000000 -7.139677
45.902344 10.000000 38.000000 -7.540648
48.500000 11.000000 11.000000 -8.967107
56.203125 12.000000 38.000000 -8.019546
60.500000 13.000000 10.000000 -8.716254
66.300781 14.000000 37.000000 -8.791194
72.703125 15.000000 13.000000 -8.763229
76.203125 16.000000 33.000000 -9.130766
86.402344 17.000000 32.000000 -8.152668
96.402344 19.000000 36.000000 -7.975923
106.703125 21.000000 39.000000 -7.742529
108.800781 22.000000 12.000000 -9.047667
116.902344 23.000000 40.000000 -8.527955
120.902344 24.000000 11.000000 -8.740450
126.703125 25.000000 40.000000 -8.737582
132.902344 26.000000 11.000000 -8.867112
137.000000 27.000000 43.000000 -9.112901
144.800781 28.000000 13.000000 -8.510533
157.101562 32.000000 10.000000 -7.982815
169.101562 34.000000 10.000000 -7.509470
193.101562 38.000000 14.000000 -5.057766
205.203125 41.000000 12.000000 -7.035861
217.101562 43.000000 11.000000 -6.811563
229.203125 45.000000 17.000000 -7.502965
```

Figure 178(normalized)

TRACK DATA MENU: *Option 10*

```
Track Data MENU 2:
  0.  PLOT Tracks
  1.  Output Tables by Track Numbers containing Number of Associated Detections and:
      a.  Minimum time and Maximum time
      b.  Range of Track Coordinates
  2.  PLOT One Track
  3.  PLOT One Track and Associated Detections
  4.  PLOT Association Cost
  5.  COMPUTE TABULAR Summary of Innovation (Detections - Track) along with corresponding plot.
  6.  OUTPUT a Table of Target ID vs. Associated Tracks
  7.  PLOT Track Covariances vs. Time
  8.  PLOT Covariance Ellipses for Detections vs. Tracks
  9.  PRINT OUT (by time tick) Selected Data Corresponding to a Particular Track
 10.  PLOT ALL Track Points Corresponding to a Particular Target ID
 11.  PLOT Velocity by Track
 12.  TRANSFER to Scan Data Menu
 13.  QUIT
MENU Choice:  10
```

Figure 179

```
SENSOR Display Submenu:
  1.  PLOT Location of Dansville ONLY
  2.  PLOT Location of Remsen ONLY
  3.  PLOT Locations of ALL Sensors
  4.  DO NOT PLOT Location of Any Sensor

SENSOR Display Submenu Choice:  3
```

Figure 167 – Repeated

```
**************************************************
INPUT Target ID (iff) NUMBER to be Viewed:  642
**************************************************
```

Figure 180

If Target ID (IFF) Number is available, *Option 10* allows the User to **view all the component Tracks that have been associated with this ID.**

This particular example has been chosen to both illustrate the operation of this *Option 10* and also to use *Option 3* to view the individual components making up **ID 642** to show how a User might be aided in his or her analysis of a possible "problem" situation.

A description of the plots for this example are on the next page.

TRACK DATA MENU: *Option 10* Continued

Figure 181 - Initial Longitude-Time plot of Target 642
Figure 182 - Initial Longitude-Time plot of Target 642 with Consecutive Associations connected by lines and individual Tracks connected by lines.
Figure 183 - Initial Latitude-Time plot of Target 642 with Consecutive Associations connected by lines and individual Tracks connected by lines.
Figure 184 - Initial Latitude-Longitude plot of Target 642 with Consecutive Associations connected by lines and individual Tracks connected by lines.
Figure 185 - **Subset menu** used to remove Aspect Ratio and Sensor Location plotting points.
Figure 186 - Latitude-Longitude plot of Target 642 with Aspect Ratio and Sensor Location plotting points removed.
Figure 187 - *Option 3* has been invoked with Track 41 and Associated Detections.
Figure 188 - Same as **Figure 187** except that Aspect Ratio and Sensor Location plotting points have been removed.
Figure 189 - *Option 3* has been invoked with Track 92 and Associated Detections.
Figure 190 - Same as **Figure 189** except that Aspect Ratio and Sensor Location plotting points have been removed.

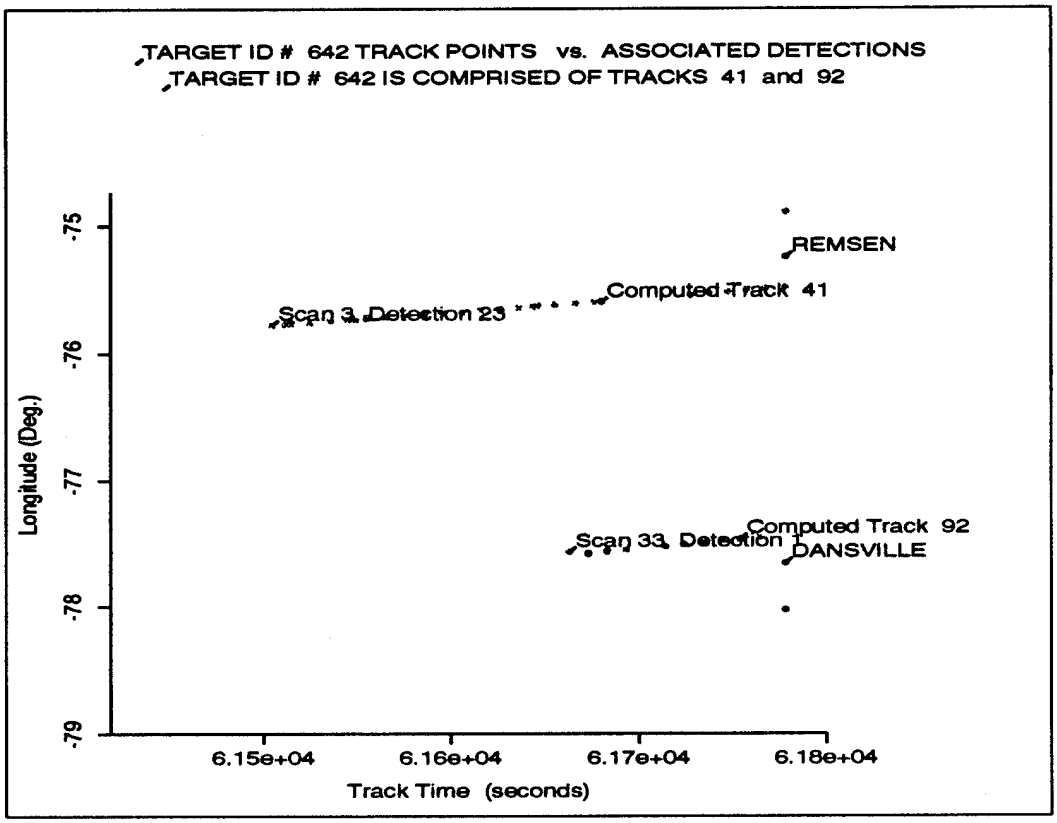


Figure 181
[Initial Longitude-Time plot of Target 642]

TRACK DATA MENU: *Option 10* Continued

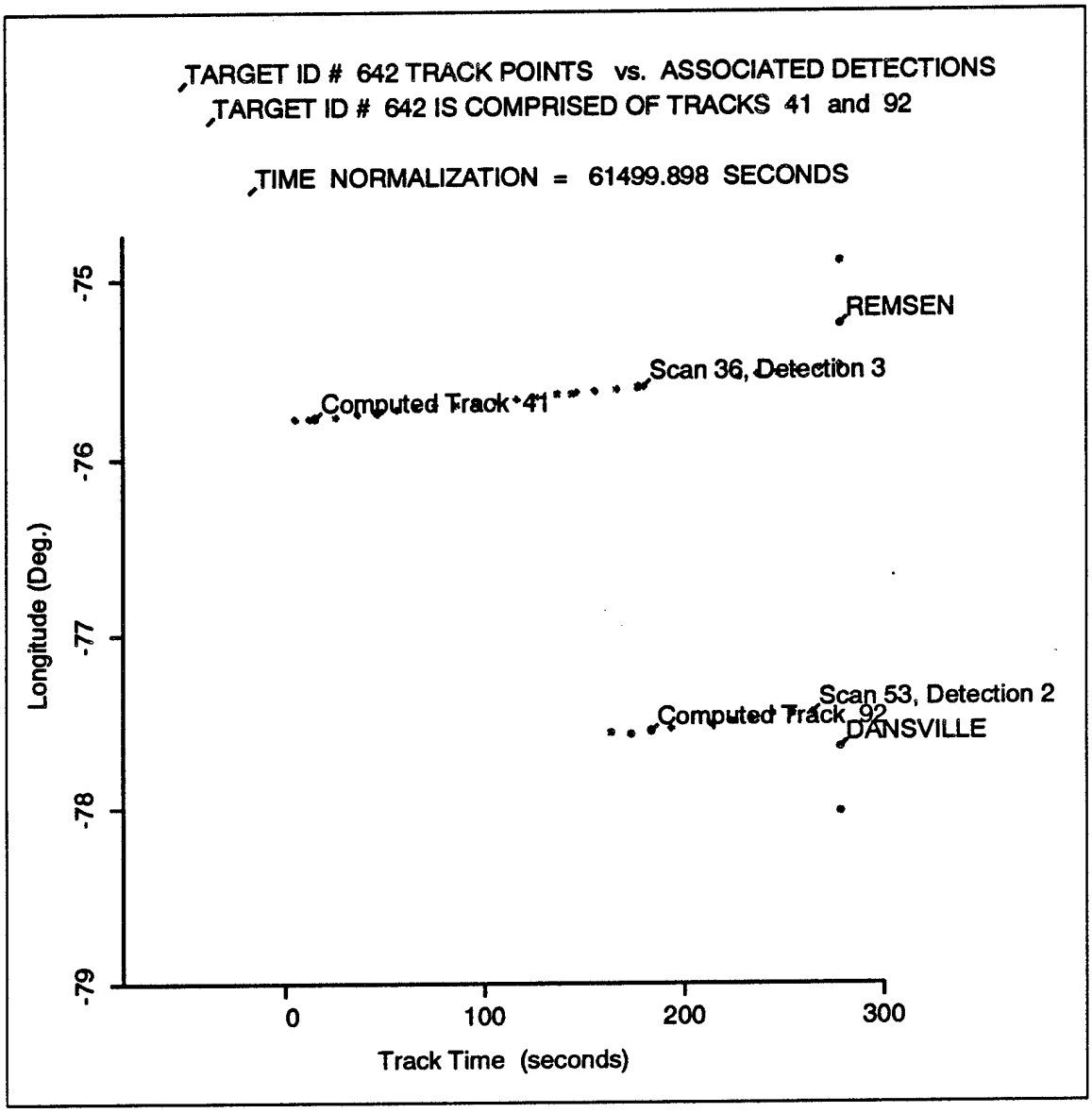


Figure 181(normalized)
[Initial Longitude-Time plot of Target 642]

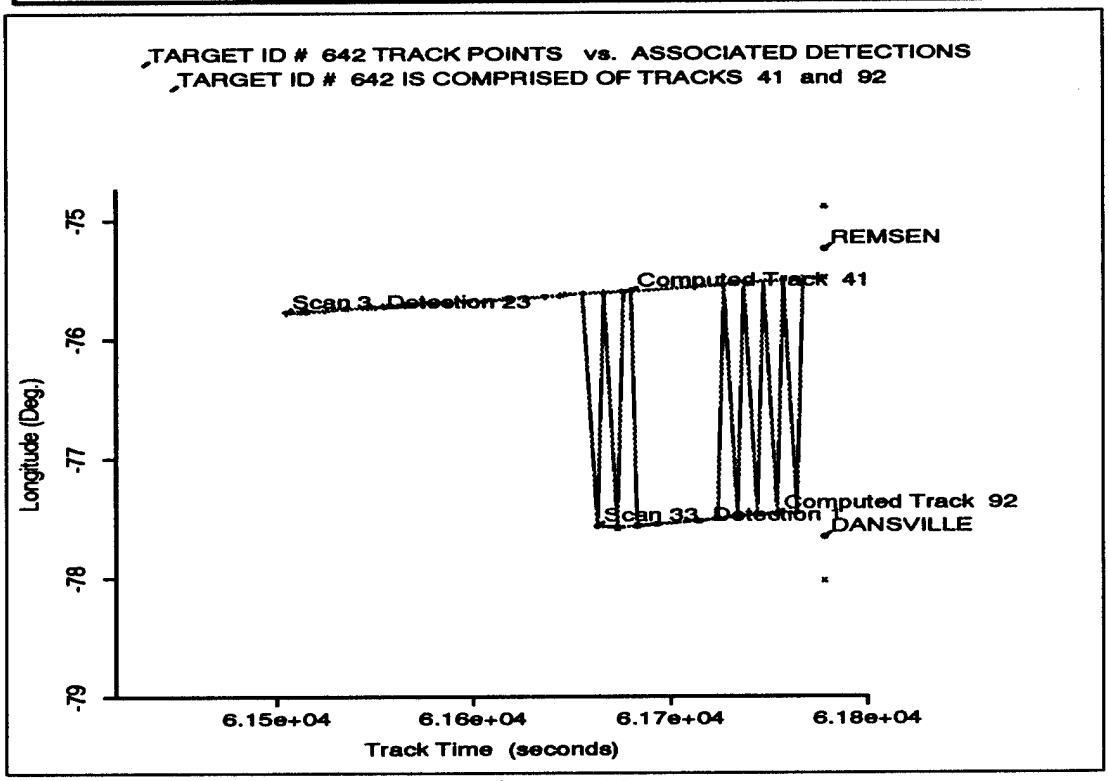


Figure 182
[Initial Longitude-Time plot of Target 642 with Consecutive Associations and individual Tracks connected by lines.]

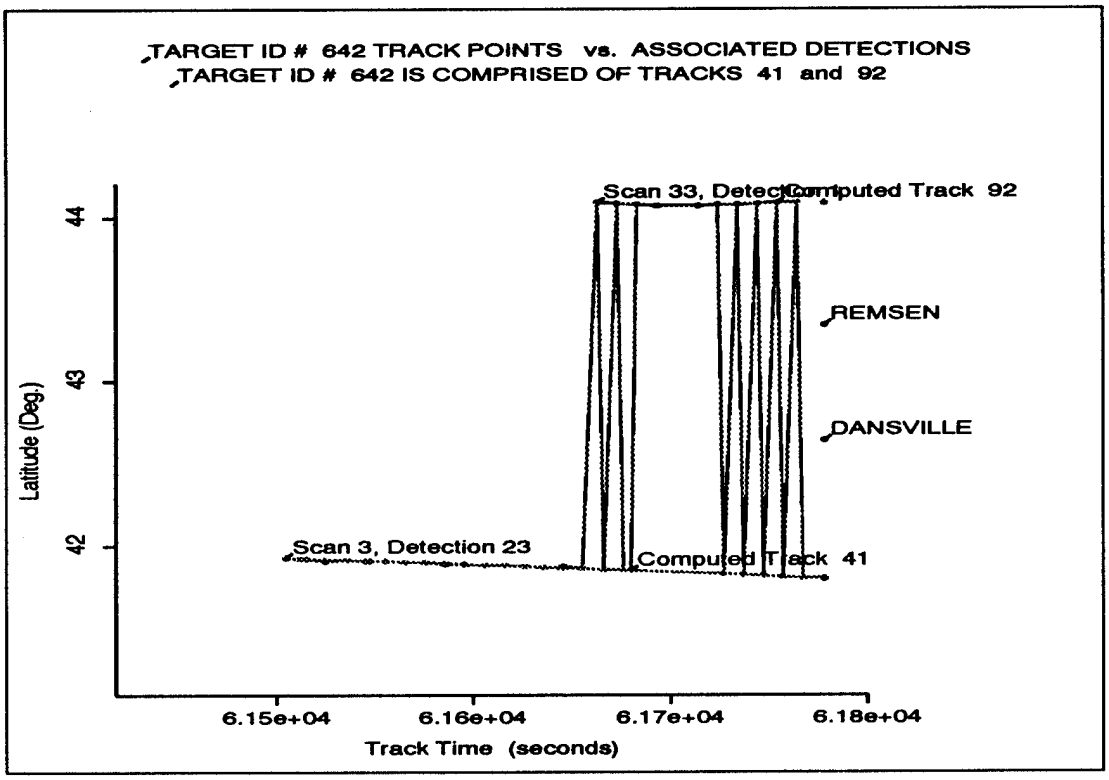


Figure 183
[Initial Latitude-Time plot of Target 642 with Consecutive Associations and individual Tracks connected by lines.]

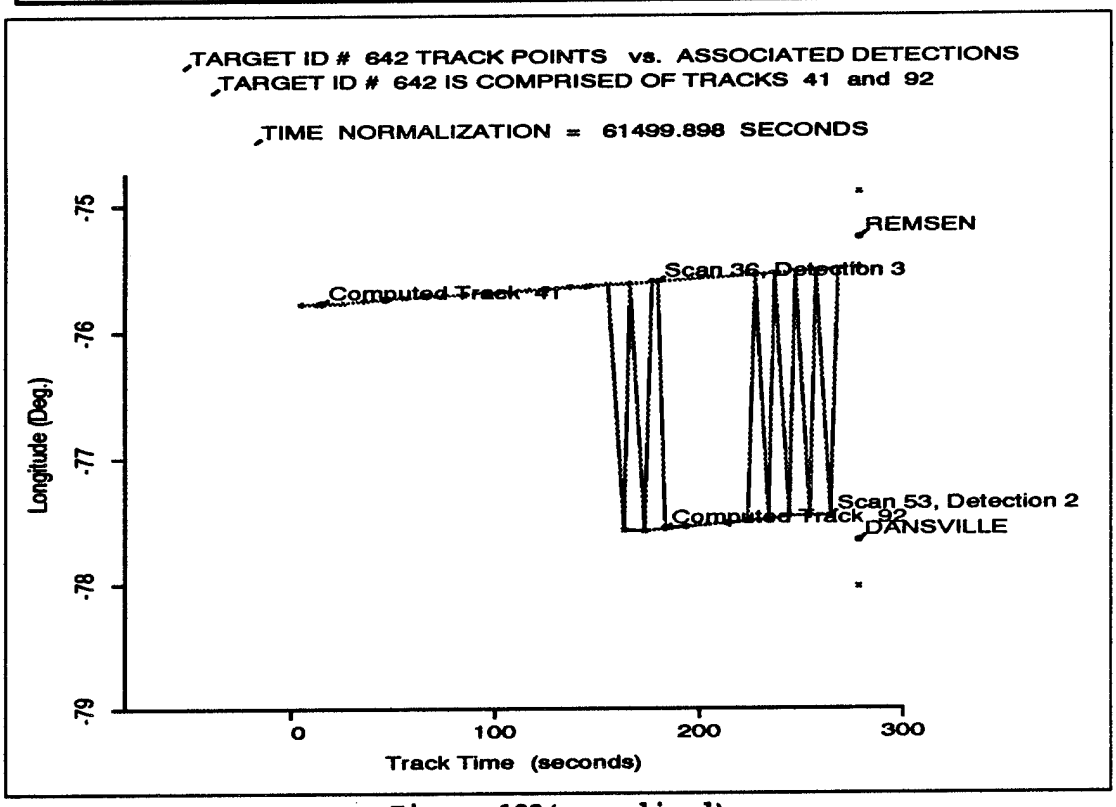


Figure 182(normalized)
[Initial Longitude-Time plot of Target 642 with Consecutive Associations and individual Tracks connected by lines.]

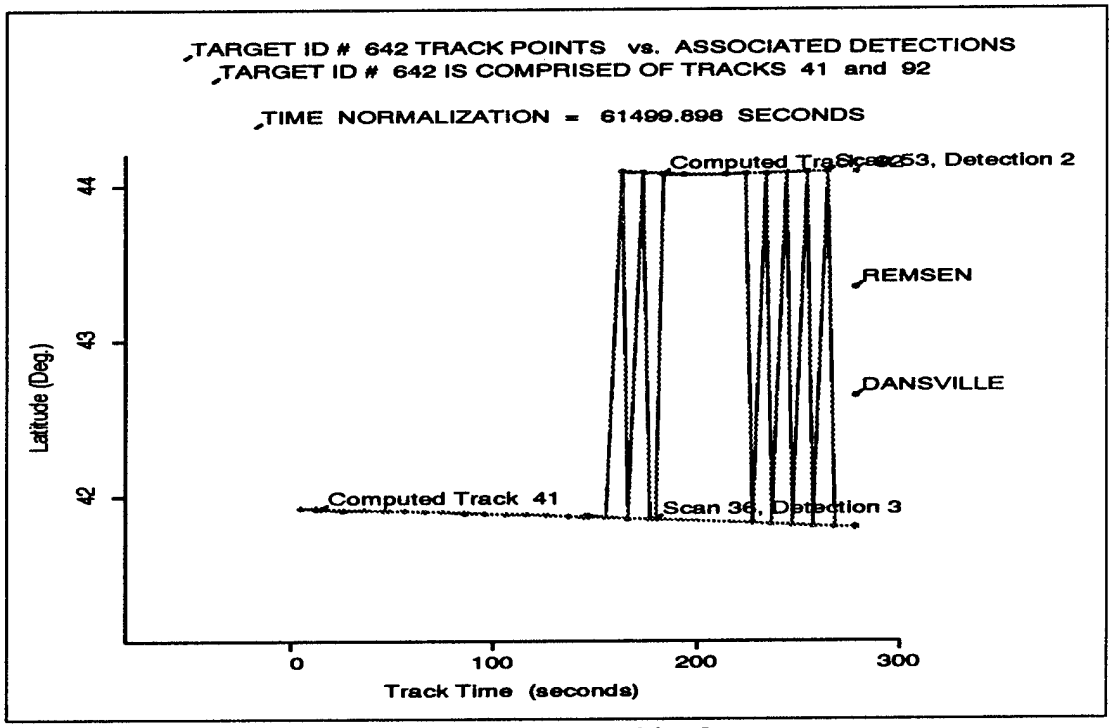


Figure 183(normalized)
[Initial Latitude-Time plot of Target 642 with Consecutive Associations and individual Tracks connected by lines.]

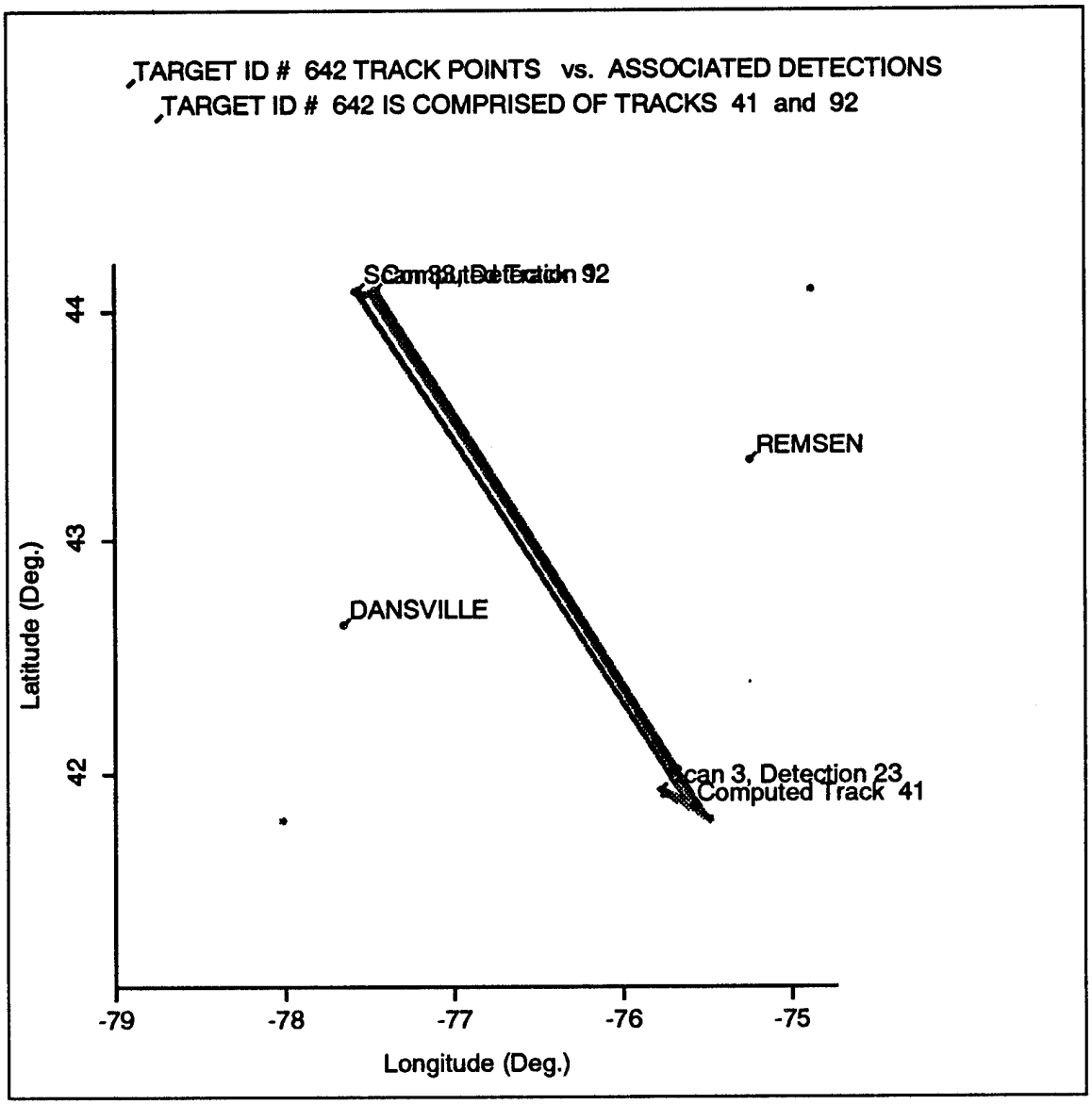


Figure 184
[Initial Latitude-Longitude plot of Target 642 with Consecutive Associations and Individual Tracks Connected by Lines.]

TRACK DATA MENU: *Option 10* Continued

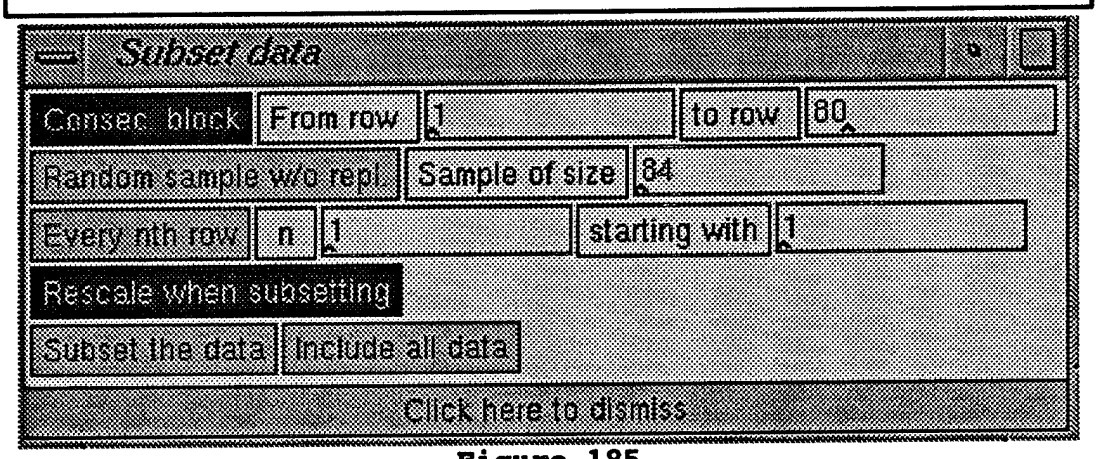


Figure 185
[Subset Menu Used to Remove Aspect Ratio and Sensor Location Plotting Points.]

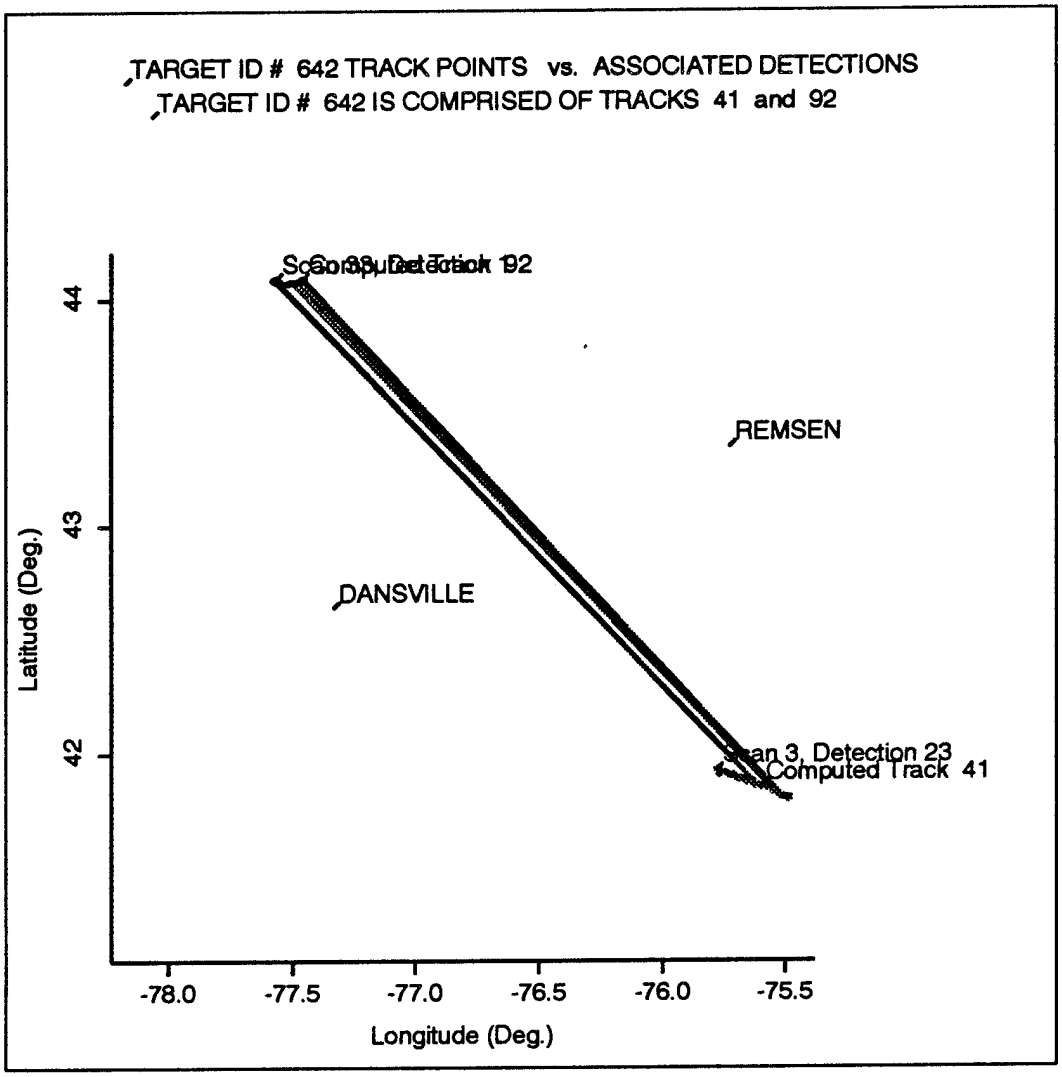


Figure 186
[Latitude-Longitude plot of Target 642 with Aspect Ratio and Sensor Location Plotting Points Removed.]

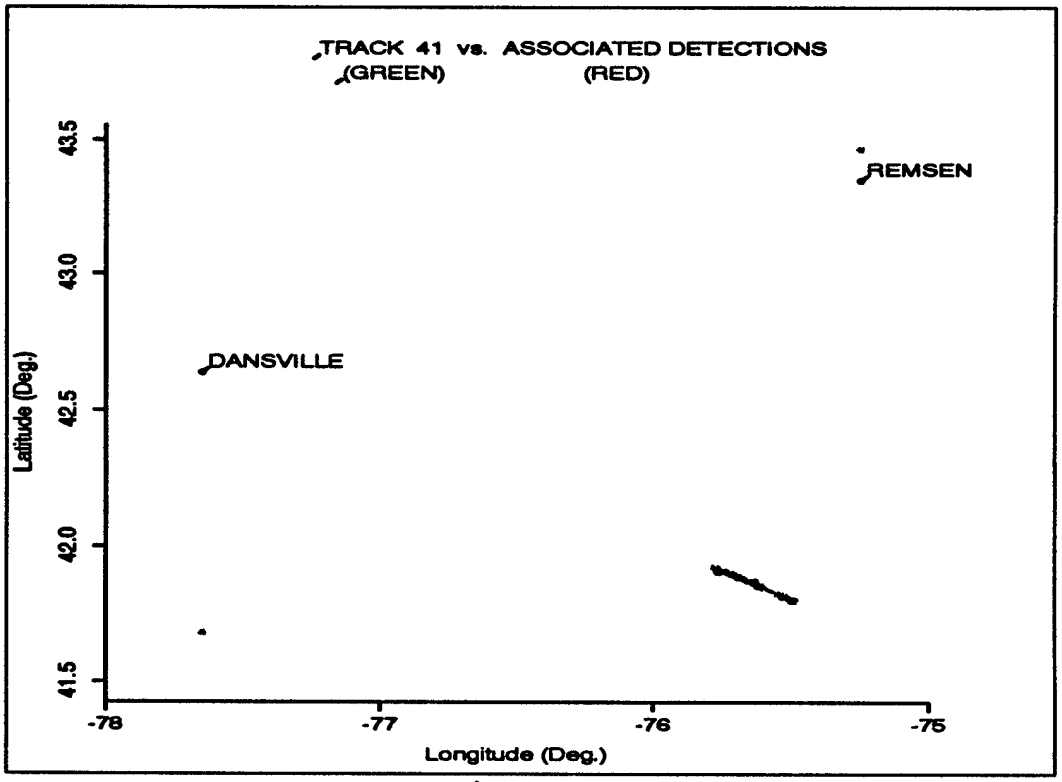


Figure 187
[*Option 3* has been invoked with Track 41 and Associated Detections.]

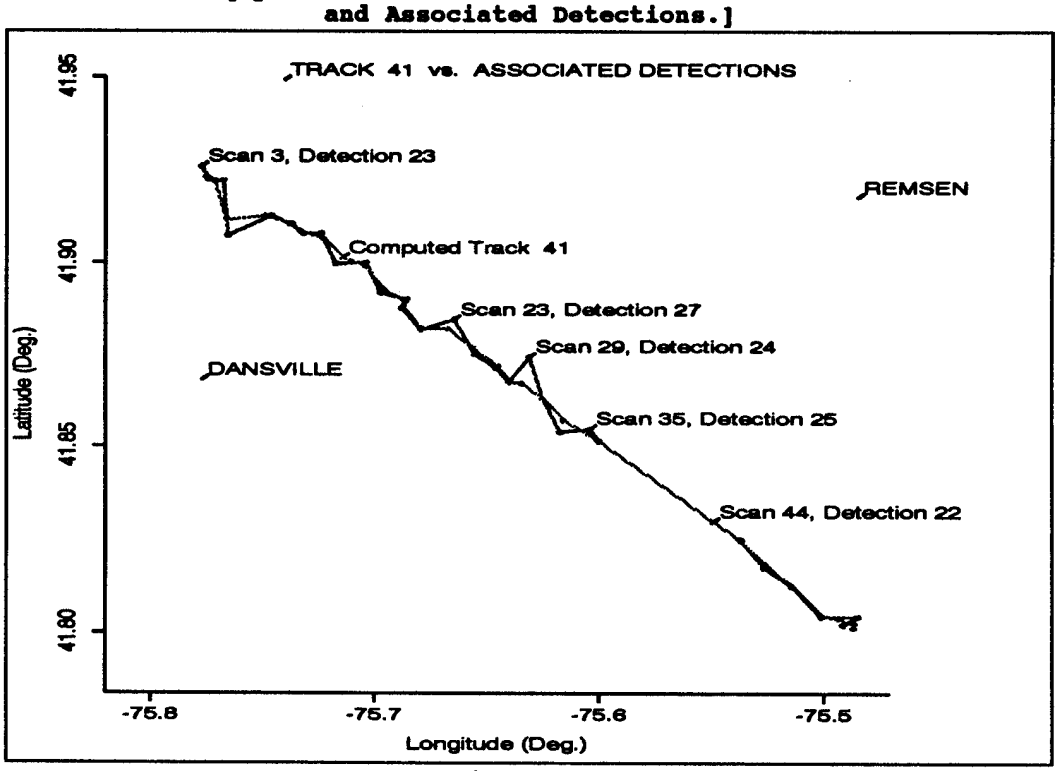


Figure 188
[Same as Figure 187 except that Aspect Ratio and Sensor Location plotting points have been removed.]

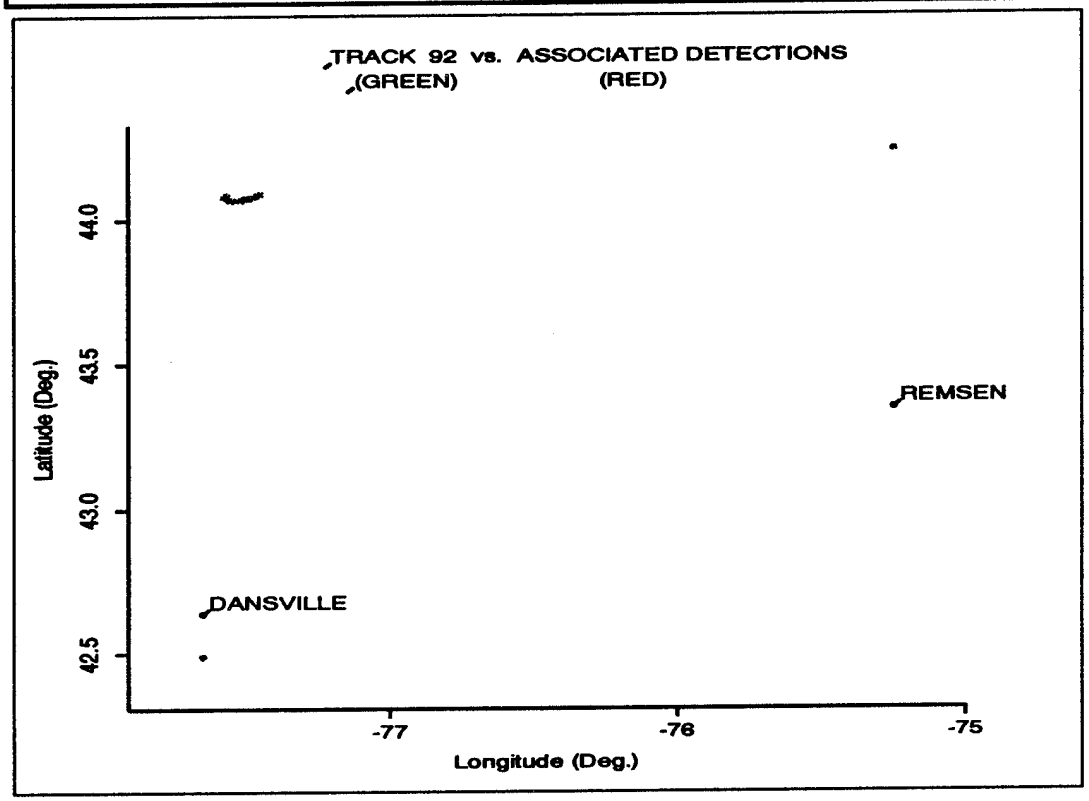


Figure 189
[*Option 3* has been invoked with Track 92 and Associated Detections.]

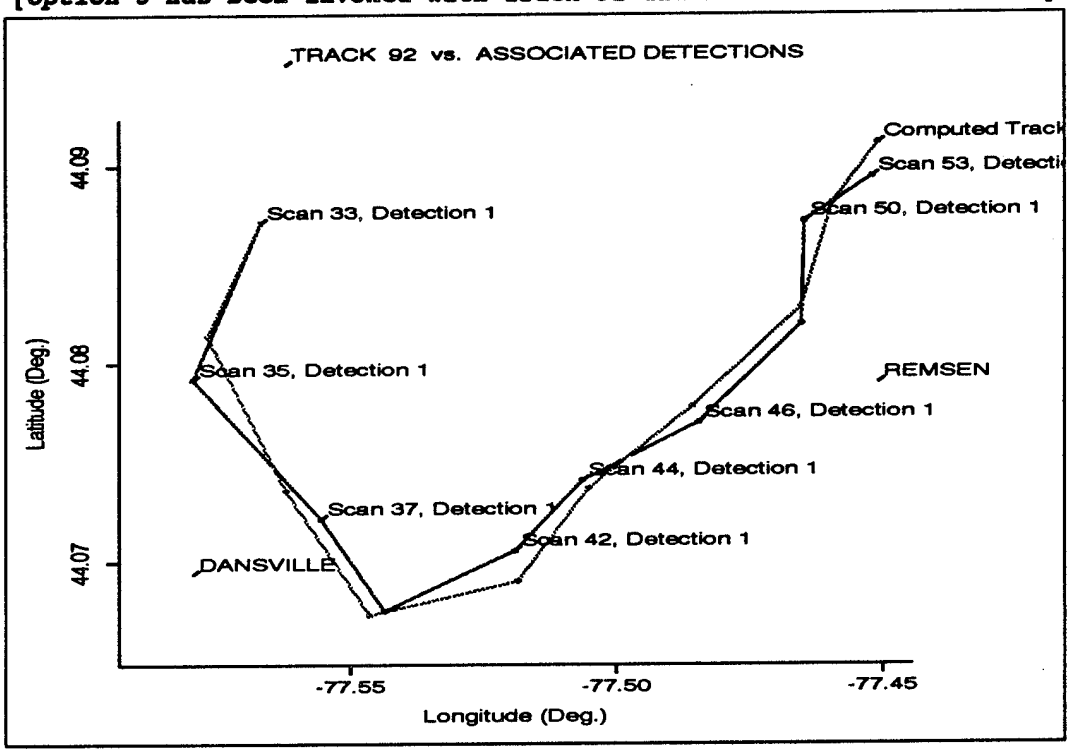


Figure 190
[Same as Figure 189 except that
Aspect Ratio and Sensor Location plotting points have been removed.]

TRACK DATA MENU: *Option 11*

```
Track Data MENU 2:
 0.  PLOT Tracks
 1.  Output Tables by Track Numbers containing Number of Associated Detections and:
     a.  Minimum time and Maximum time
     b.  Range of Track Coordinates
 2.  PLOT One Track
 3.  PLOT One Track and Associated Detections
 4.  PLOT Association Cost
 5.  COMPUTE TABULAR Summary of Innovation (Detections - Track) along with corresponding plot.
 6.  OUTPUT a Table of Target ID vs. Associated Tracks
 7.  PLOT Track Covariances vs. Time
 8.  PLOT Covariance Ellipses for Detections vs. Tracks
 9.  PRINT OUT (by time tick) Selected Data Corresponding to a Particular Track
10.  PLOT ALL Track Points Corresponding to a Particular Target ID
11.  PLOT Velocity by Track
12.  TRANSFER to Scan Data Menu
13.  QUIT
MENU Choice:  11
```

Figure 191

```
**************************************************
INPUT Track Number to be Viewed:  41
**************************************************
Minimums: 0.000000 -0.092753 -0.000901 0.092757
Maximums: 0.119851 0.000000 0.009164 0.120201
[Aspect Ratio is NOT being used.]
```

Figure 192

Option 11 offers the User an opportunity to plot a given Track's velocity. The **Figures** (with NORMALIZED and UN-NORMALIZED times) which follow are examples of that capability.

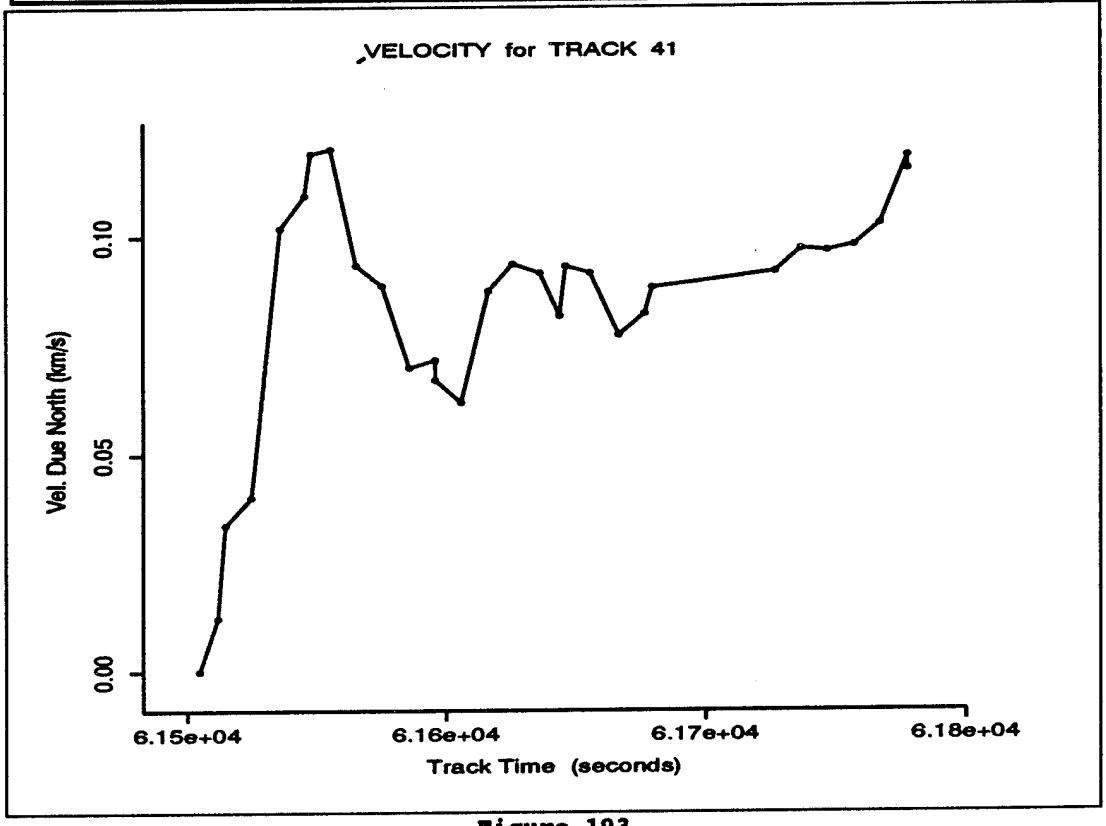


Figure 193
[Track 41 Velocity due North (km/sec)]

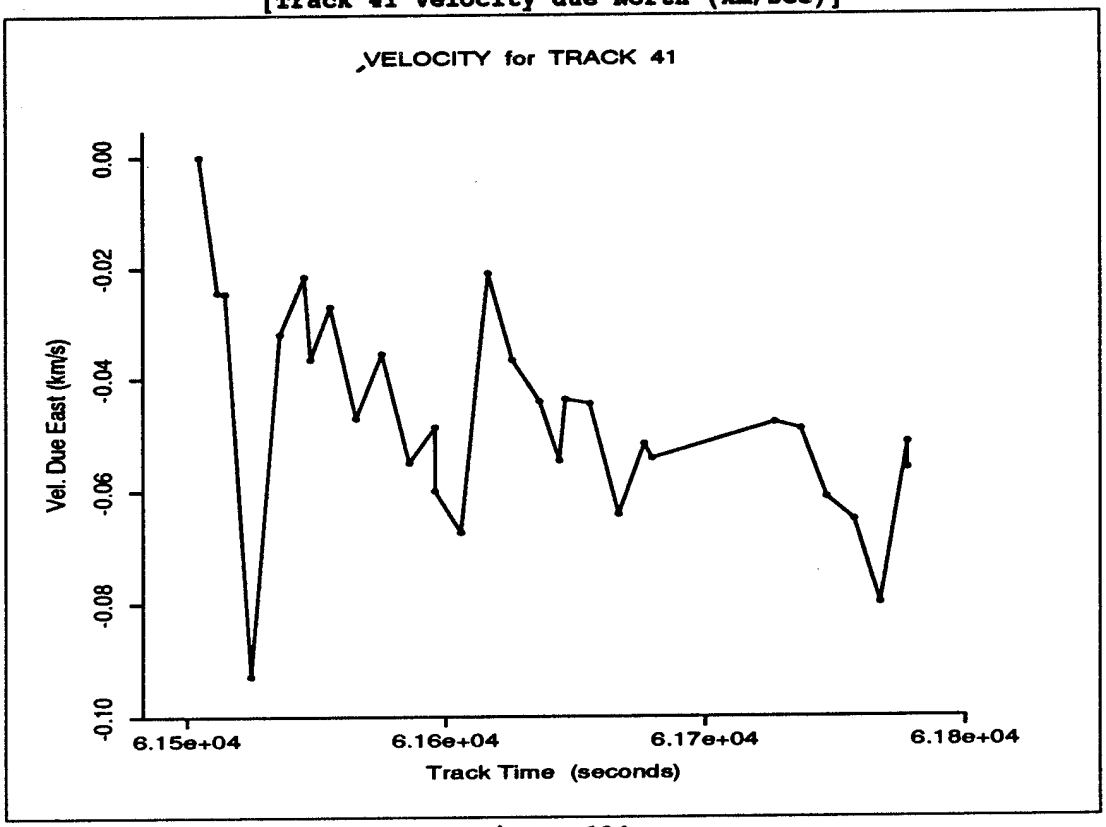


Figure 194
[Track 41 Velocity due East (km/sec)]

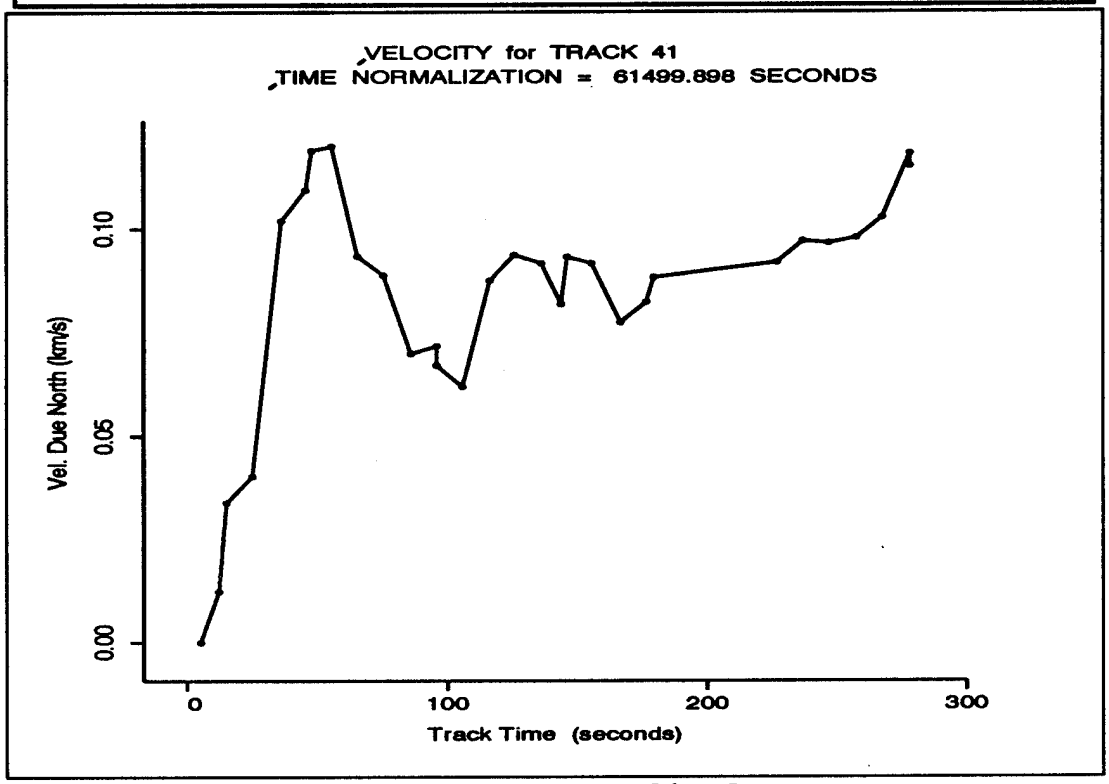


Figure 193(normalized)
[Track 41 Velocity due North (km/sec)]

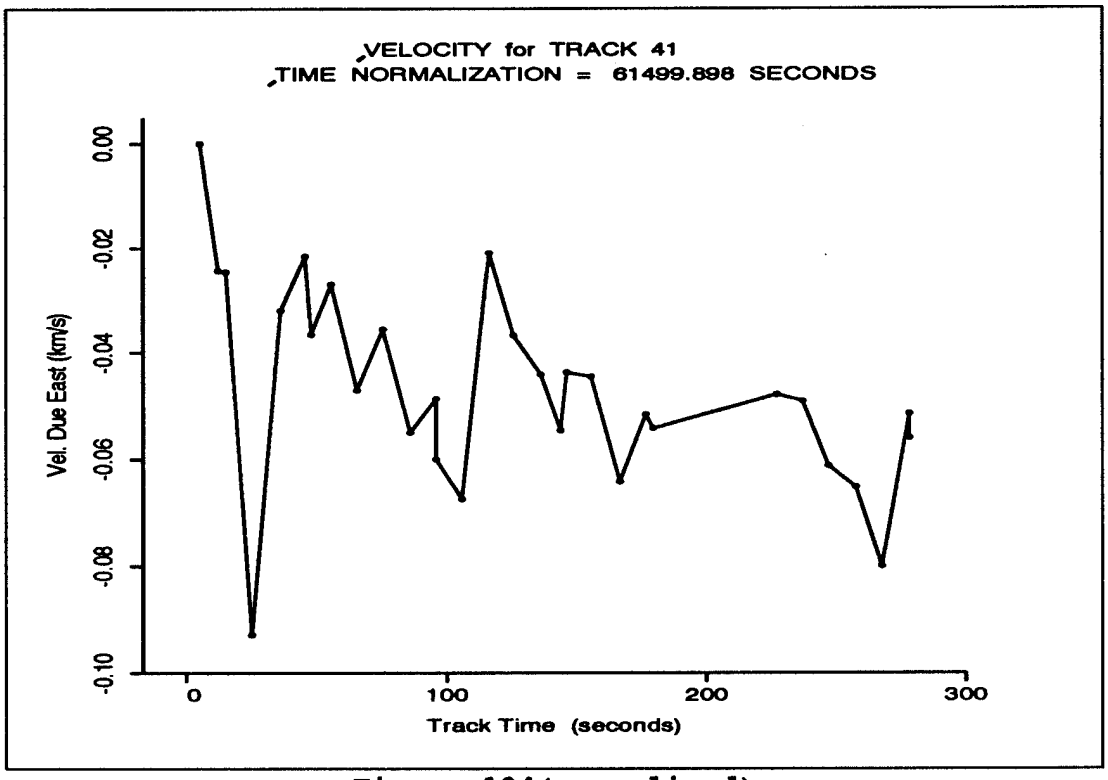


Figure 194(normalized)
[Track 41 Velocity due East (km/sec)]

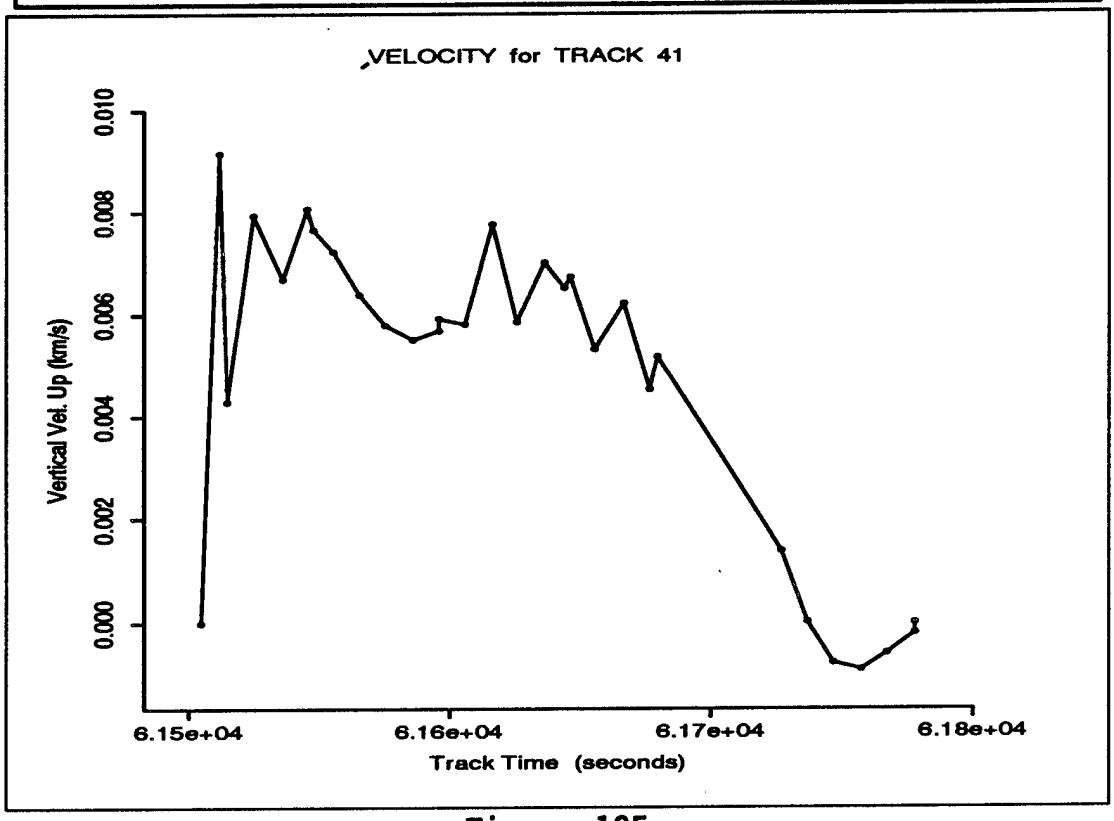


Figure 195
[Track 41 Vertical Velocity Up (km/sec)]

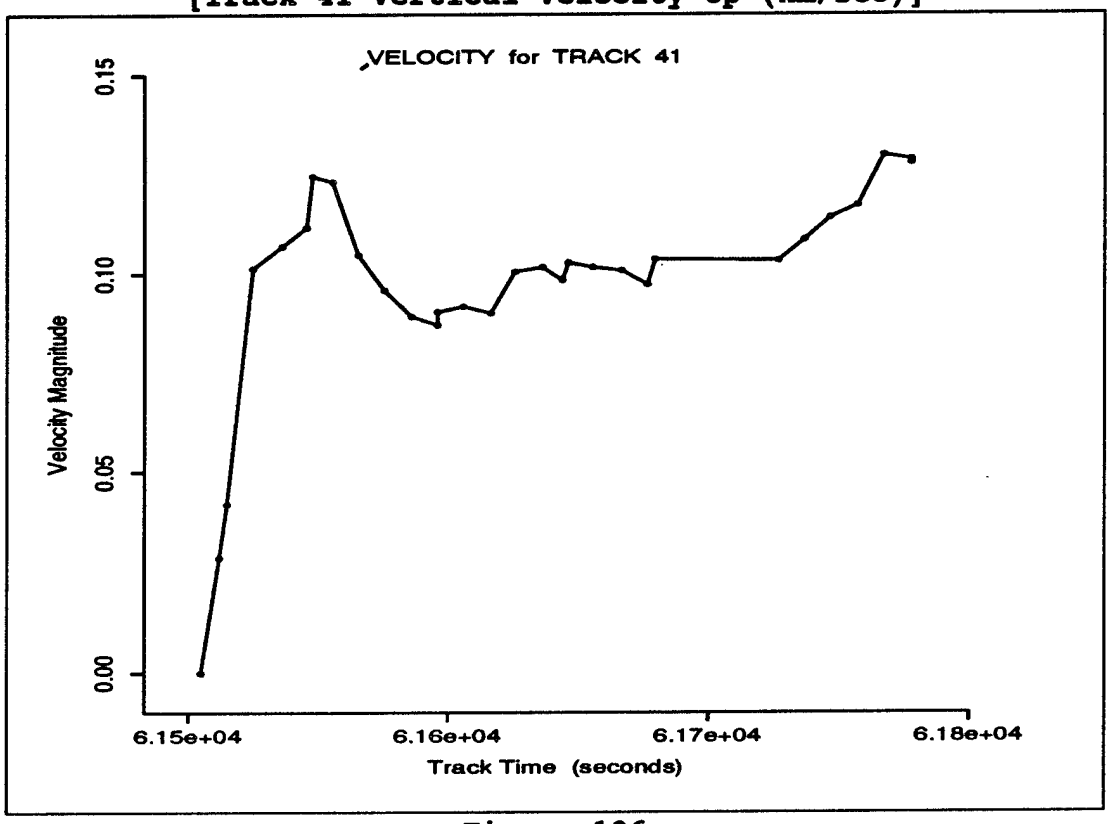


Figure 196
[Track 41 Velocity Magnitude]

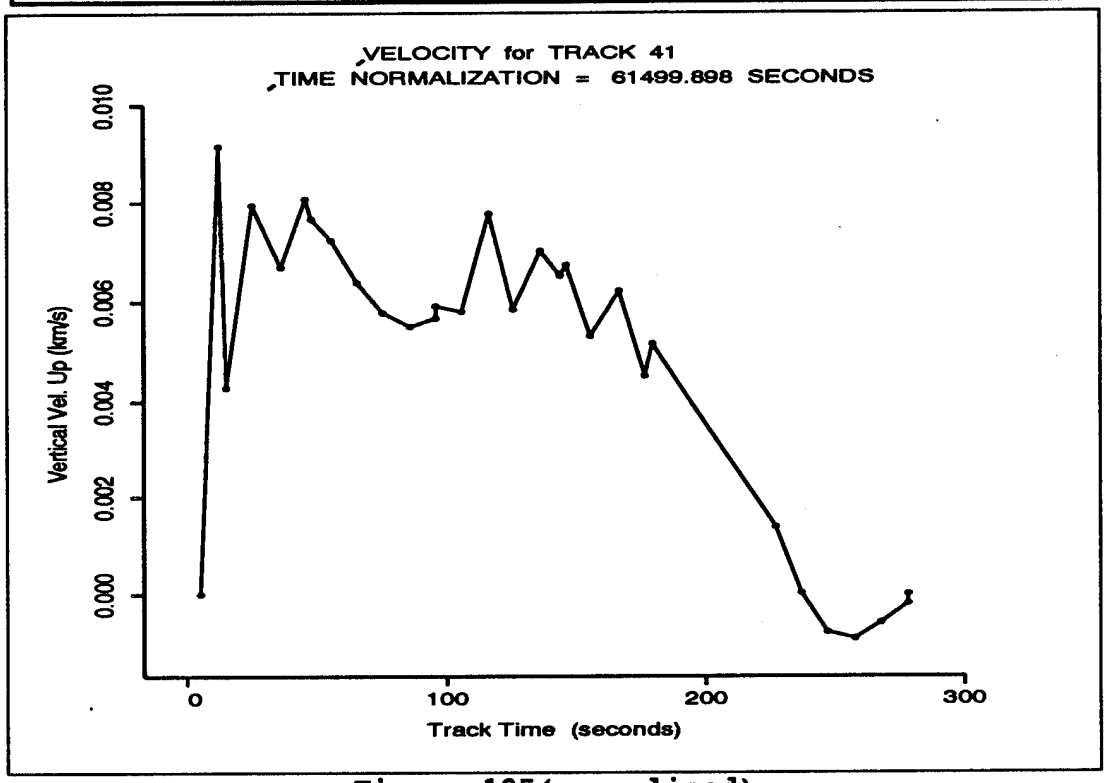


Figure 195(normalized)
[Track 41 Vertical Velocity Up (km/sec)]

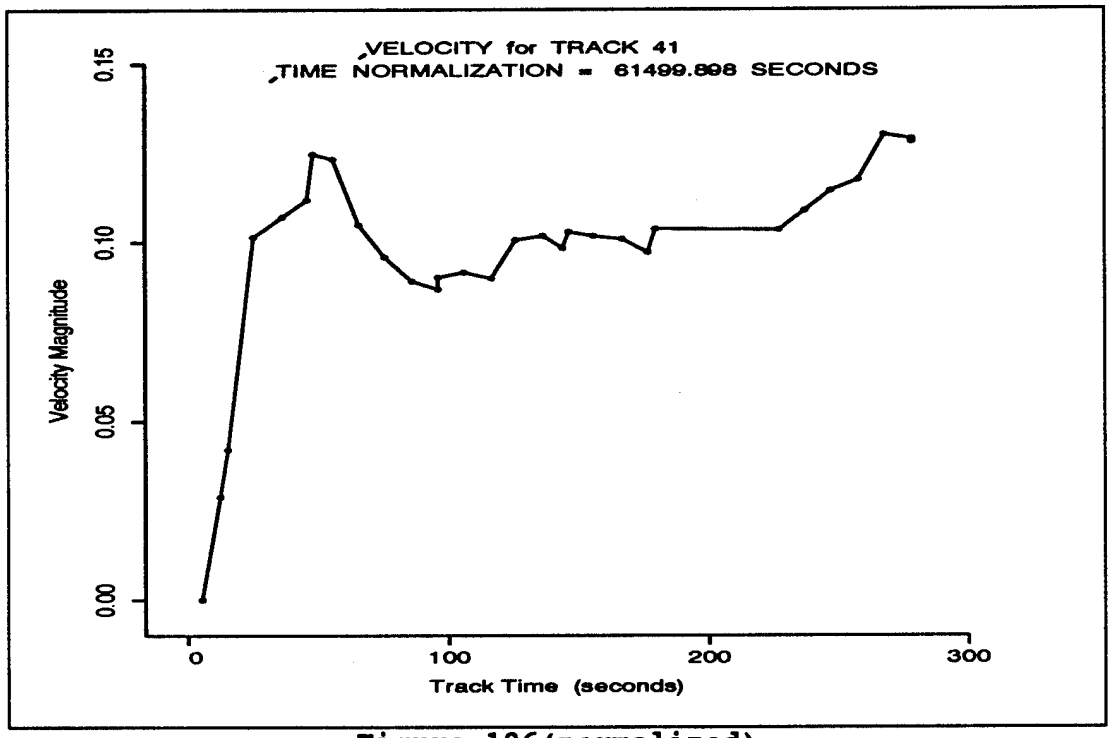


Figure 196(normalized)
[Track 41 Velocity Magnitude]

Rome Laboratory

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